Vol. 10 | No. 3 | October - December 2022

Kañch

Celebrating 80 Years of AIGMF 1944 2023
The All India Glass Manufacturers' Federation

Quarterly Journal of **The All India Glass Manufacturers' Federation**
Bi-lingual

Special Feature

Upcoming Events

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International Year of Glass 2022

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Kañch
Quarterly Journal of **THE ALL INDIA GLASS MANUFACTURERS' FEDERATION**

Vol. 10 | No. 3 | October-December 2022

Contents

AGI glaspac has been designing and manufacturing glass bottles and jars for over 50+ years, and we're still leading the way when it comes to quality, flexibility and innovation. We have positioned ourselves as one of the leading container glass manufacturers in the country. With three state-of-the-art manufacturing facilities, one in Hyderabad and the other two at Bhongir (Telangana) both strategically located in South–Central India, where key raw materials are available in abundance. With both facilities put together, AGI melts 1754+ tonnes of glass per day and produces container glass bottles ranging from 2ml to 4000ml. AGI is in a position to provide glass containers in various colours which can offer great marketing advantages from a branding point of view.

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From President's Desk

First ever AIGMF's Hybrid meeting as well as Executive Committee meeting was organised at Radisson Blu Hotel in Guwahati, ASSAM on Dec 10, which was hosted by North East Sillimanite Refractories, an Affiliate Member of The All India Glass Manufacturers' Federation (AIGMF).

The event saw technical presentations by the Competition Commission of India, GoI; SEFPRO/SEPR India, concluding IYoG 2022 lecture by CGCRI and release of AIGMF's 2023 calendar on 'Green as Glass'. All events were centered around International Year of Glass 2022 celebrations.

A highlight of the meeting was the release of the AIGMF calendar 2023 on the theme 'Green as Glass', a project centered on IYoG celebrations and featuring 2022 winners of the AIGMF's annual contest for youth: the first-ever poem/essay writing contest on 'Green as Glass' that coincided with the International Youth Day. As part of the educative process 1500 prints have been distributed to AIGMF Members, Associations, Embassies, Chief Sec's, CMs, LGs, Central Universities, Central Government, DU Colleges/top 150 Schools in India, Education Sec's, Glass Processors, CGCRI, Health Departments, Cultural Centres, DTU, Secy's to GoI, UPGMS, CDGI, others etc. The online version is available at www.aigmf.com

In the Ex Com meeting on Dec 10, upon voluntary resignation of Mr. Hargun Bhambhani, Mr. Shreevar Kheruka, Vice Chairman and Managing Director of Borosil Ltd., was appointed as Vice President of the AIGMF. Our gratitude goes to Mr. Bhambhani whose presence in office bearership will always be missed.

At the invitation of The All India Glass Manufactures' Federation (AIGMF), Dr. Arun Varshneya, President of Society of Glass Technology, United Kingdom and Member of the International Year of Glass 2022 held interactive sessions with the students of St. Thomas School, New Delhi and Delhi Technological University on Nov 30 at Delhi.

The program at the school saw a participation of around 300 students from 9^{th} and 11^{th} standards and 80 members at the DTU. The topic chosen by Prof. Varshneya was Stronger Glass Products and an Overview on IYoG (International Year of Glass 2022).

A tribute was paid by the Eco-club Students/Teachers, Prof. Varshneya/AIGMF to Mahatma Gandhi who used to walk at the St. Thomas School grounds by holding glass bottles with Swachh Bharat Abhiyaan (clean India campaign) logo, adopted from the spectacles of Mahatma Gandhi by the Govt. of India; and IYoG logo.

All participating students, Teachers and Professors were given Mementoes- glass bottles with IYoG logo specially made by AGI glaspac and HNG out of the recycled glass.

Industry lost one of its stalwarts in glass manufacturing, Mr. Brij Mohan Labroo, Chairman of Asahi India Glass Ltd., who passed away on Nov 7 at the age of 92. Mr. Anup Kumar Dasgupta, Chairman of FGK Thermal *(an Affiliate member of the AIGMF)* left for heavenly abode on Oct 6. A brief silence was kept in the AIGMF's Ex-Com meeting on Dec 10 at Guwahati as a respect to the departed souls.

The next Executive Committee meeting is slated to be held at Jaipur on March 25 where in addition to the technical presentations, investment opportunities in the state of Rajasthan will be discussed with RICCO officials. All Members are invited to be a part of these discussions and to celebrate 80 years of the AIGMF ■

Sanjay Agarwal
President AIGMF and
Director, Kwality Glass Works, Firozabad

GLASS News

AIGMF MEMBERS AT CPHI-PMEC INDIA 2022

AIGMF Member companies participated at CPHI & PMEC India that provided the one-stop shop to source cost-effective pharma solutions under one roof from Nov 29- Dec 1, 2022 at India Expo Centre, Greater Noida, Delhi NCR.

As the pharma industry looks increasingly towards India for high quality, low cost pharma solutions, CPHI & PMEC India provided an ideal event for companies wanting to pick up on the latest trends and innovations the market has to offer.

SCHOTT Poonawalla had a vibrant booth with the motto "rebranding" highlighted the Ready-To-Use portfolio of tubular glass vials, pre-fillable syringes, and cartridges. The booth covered a space of $72m^2$.

"After 2 years of restrictions due to COVID-19 pandemic, it was a great opportunity to reconnect with customers, partners, and colleagues on this platform over discussions on drug containment solutions, technical collaboration and much more. With 50 pre-scheduled meetings, 1 scientific expert talk, 3 days of complete engagement between the sales colleagues, product experts, customers, and partner discussions, it is sure to say that CPHI-PMEC 2022 was a success.", said Ms. Dipanwita Chakraborty of Schott Poonawalla Ltd.

SCHOTT Poonawalla received special jury recognition award under

Kapoor Glass at CPHI & PMEC India

the 'Excellence in Export Promotion' category for COVID-19 pandemic vaccination drive during FY 2021-22.

During the COVID-19 pandemic, as vaccine vial capacity fell short in global market, India played a key role as COVID-19 vaccine vial supplier. SCHOTT Poonawalla's role in rolling out vaccine vials in the shortest possible time, contributed to major shift in the process.

Mr. Eric L'Heureux, Managing Director, SCHOTT Poonawalla and Ms. Sangeetha Shenvi, Vice President-Sales, SCHOTT Poonawalla were present at the final award ceremony to collect the award.

"Kapoor Glass was pleased to exhibit at CPHI Worldwide for the sixth year running, thereby showcasing their technical expertise in producing high quality products with an emphasis on user and patient safety. The company is now exporting high quality glass ampoules, vials, cartridges and test tubes to 34 countries with over 90% of exports taking place to Western Europe and other regulated markets across the globe."

"The Kapoor Glass team has consistently seen a steady increase in footfall at each pharma exhibition which is testament to its uncompromising commitment to global quality and supply standards. The company was represented by brothers Mr. Udit and Dhruv Kapoor and their Latin American Business Development team."

MEETING WITH PRESIDENT OF SOCIETY OF GLASS TECHNOLOGY

President of Society of Glass Technology Prof. Arun Varshneya was welcomed at AIGMF office on Nov 29.

He was presented with a calendar glass bottle carrying IYoG logo; specially designed by AGI Greenpac.

Secretary Mr. Vinit Kapur discussed on the possibilities to collaborate Indian glass manufacturers with latest technology know how from EU companies and events that could be organized next year along with the Society of Glass Technology, UK in India; discussions were also held on how to further develop academic linkages.

WELCOMING HON. TREASURER ON HIS MAIDEN VISIT TO SECRETARIAT

Hon. Treasurer AIGMF and Director of Gopal Glass Works Ltd., Mr. Purvish M. Shah was welcomed during his maiden visit to the AIGMF Secretariat on Nov 30.

He was presented with a calendar glass bottle 2023; specially designed by AGI Greenpac.

AIGMF/CGCRI MEETING WITH PROF. MANOJ CHOUDHARY

On Nov 15, Secretary AIGMF along with CGCRI officials carried out discussions at CGCRI Kolkata to conduct test events before ICG Congress at Kolkata in 2025, Integration of glass manufacturers at glasspex/glasspro 2023 shows and other areas of Glass.

Momento Glass Calendar bottle of IYoG 2022 was presented to Prof. Manoj Choudhary, Former President International Commission on Glass, Adjunct Prof. Materials Science & Engineering, The Ohio State University and President, MKC Innovations, LLC (USA).

PASSING AWAY OF ANUP KUMAR DASGUPTA

Mr. Anup Kumar Dasgupta (born 1945); Chairman, FGK THERMAL *(an Affiliate member of AIGMF)* left for heavenly abode on Oct 6.

A Bachelor of Engineering (Electrical) from Jadavpur University, Mr. Dasgupta was actively involved with the ceramic & glass industry in India from 1968 and was the founding member of FGK India in 1978 & FGK THERMAL in 1991.

He was also currently the working President of Ex - Andaman Political Prisoners' Fraternity Circle.

SAD DEMISE OF BRIJ MOHAN LABROO

Mr. Brij Mohan Labroo, Chairman Asahi India Glass Ltd., left for heavenly abode on Nov 7.

Mr. B M Labroo was 92 years old and recently faced some age-related health issues. He was the founder promoter of AIS and had been on the Board of the company since 1985.

An online prayer meeting *(Puja ceremony)* was organised by AIS on Nov 19 in remembrance of Mr. B M Labroo.

BOROSIL RENEWABLES COMPLETES ACQUISITION OF 86% IN EUROPE'S LARGEST SOLAR GLASS MAKER INTERFLOAT GROUP

Borosil Renewables Ltd. (BRL) has announced the acquisition of 86% stake in Interfloat Group, Europe's largest solar glass manufacturer, through its overseas wholly-owned subsidiaries.

The Interfloat Group is based in Germany and Lichtenstein and has been serving customers in the solar industry since 2008. It consists of GMB Glasmanufaktur Brandenburg GmbH (GMB), which has a production plant with a capacity of 300 tonnes per day (as of April 2022) near Berlin, and Liechtenstein-based Interfloat Corporation, well known as a supplier to the European glass market.

GMB operates a solar glass plant with a production capacity of 300 tonnes per day (tpd). With its acquisition of the Interfloat Group, Borosil Renewables's solar glass manufacturing capacity will grow to 750 tpd from the current 450 tpd, an increase of 66%. This capacity of the combined entity will further increase to 1,300 tpd in the next two months with the commissioning of a new furnace with a capacity of 550 tpd in India.

This acquisition will make a wider range of solar glass available to BRL's expanded customer base in Europe. Borosil leverages its highly efficient production technology to bring greater productivity and a lower carbon footprint to the European entity.

"The overseas wholly owned subsidiaries of the Company [Borosil Renewables], namely, Geosphere Glassworks GmbH and Laxman AG, have completed the acquisition of 86% stake in GMB Glasmanufaktur Brandenburg GmbH (GMB) and Interfloat Corporation (Interfloat), respectively. Consequently, both GMB and Interfloat have become step-down subsidiary companies of the company," stated Borosil Renewables in a stock exchange filing.

The acquisition of Interfloat will make a broader range of solar glass available to Borosil Renewables' expanded customer base in Europe. Besides, "Borosil's expertise in achieving high efficiency in the manufacturing process to enhance throughput and lower costs will bring economies of scale to Interfloat's expansion and manufacturing plans while reducing the carbon footprint of its European operations," stated Borosil earlier.

Borosil Renewables plans to further grow its India capacity from 1,000 TPD as of December end to 2,100 TPD by 2024.

"Furthermore, Borosil is committed to investing in manufacturing in Europe and will be increasing capacity at GMB's Tschernitz plant at an appropriate time in the near future. This means that BRL and Interfloat will be able to supply significantly higher volumes of solar glass to their present and new customers by improving the serviceability as a result of the production from two locations now," stated the company.

SHREEVAR KHERUKA APPOINTED VICE PRESIDENT OF AIGMF

In the Ex Com meeting on Dec 10, upon voluntary resignation of Mr. Hargun Bhambhani, Mr. Shreevar Kheruka, Vice Chairman and Managing Director of Borosil Ltd., was appointed as Vice President of the AIGMF.

Our gratitude goes to Mr. Bhambhani whose presence in office bearership will always be missed.

Mr. Shreevar Kheruka is the CEO and Managing Director of Borosil Glass Works Ltd. He has been with the company since 2006 and has led it through a period of substantial organic and inorganic growth. From a single product and single brand organization, Borosil is now evolving as a multi-product, multi brand and multi-channel consumer centric organization.

Mr. Kheruka earned a dual degree from the University of Pennsylvania, an Ivy league institution based in Philadelphia, PA. His two degrees include a Bachelor of Science in Economics with concentrations in Finance and Entrepreneurship from the Wharton School and a Bachelor of Arts in International Relations from the College of Arts and Sciences. During university, he worked on the foreign exchange options and derivatives desk at Goldman Sachs in New York, NY for a summer internship. He was also appointed a Benjamin Franklin Scholar while at university. After graduation, Mr. Kheruka worked at Monitor, a consulting firm based in Cambridge, MA before returning to India in 2006.

Mr. Kheruka is a member of Mumbai chapter of the Young Presidents

Organization (YPO) and has also been chosen as a Young Global Leader (YGL) by the World Economic Forum. He is a passionate sports fan and has been supporting India's dream for more medals at the Olympics through the Borosil Foundation.

80 YEARS LOGO OF AIGMF UNVEILED

In the Ex Com meeting of the AIGMF, 80 years logo was unveiled.

Founded in 1944, The All India Glass Manufacturers' Federation (AIGMF) is a not for profit National Apex Body of the Indian Glass Industry, representing all segments and sectors.

AIGMF undertakes socially responsible steps as a voluntary service to society, thereby bringing increased awareness of Glass.

GLASSTEC AND A+A UNDER NEW MANAGEMENT: LARS WISMER TO BECOME NEW DIRECTOR

As of 1st of December 2022, Mr. Lars Wismer (49) will lead the team of glasstec, the world's leading trade fair for the glass sector, as well as A+A, International Trade Fair for Safety, Security and Health at Work. As Director, he will be responsible

not only for these leading trade fairs but also for the international Glass Technologies portfolio with the glasspex and glasspro trade fairs for the Indian market as well as the international Occupational Safety & Health portfolio including the TOS+H, CIOSH and OS+HA trade fairs.

"I look forward to being back on board at Messe Düsseldorf again and to working with a strong team to further expand the leading position of the two leading trade fairs and the international portfolios," explains Mr. Wismer.

Mr. Wismer is a familiar face at Messe Düsseldorf. Having worked as a Senior Project Manager for 16 years, the event professional knows Messe Düsseldorf very well. In addition, he has extensive experience in the management and marketing of large, international events. Most recently he was in charge of D.SPORTS Events, Sales, PR/Communication and Marketing as Executive Director Sports at D.LIVE GmbH & Co. KG.

"I am delighted that we have been able to win back Lars Wismer for Messe Düsseldorf. He has many years of expertise in managing international events in Germany and abroad," says Ms. Petra Cullmann, Executive Director at Messe Düsseldorf.

The next glasstec will be held at the Düsseldorf Exhibition Centre in Germany from October 22-25, 2024. For more information visit: www.glasstec-online.com

AIGMF AT WORLD SODA ASH CONFERENCE

The World Soda Ash Conference 2022 was held from Oct 11-13 at Sorrento, ITALY.

The All India Glass Manufacturers Federation supported the conference as one of the media partners. AIGMF's logo was displayed under Partners of the event.

AIGMF Members were entitled for a discount on the participation, which saw a few member companies participating in the event.

उत्तर प्रदेश सरकार फिरोज़ाबाद के कांच के निर्यात को 1,000 से बढ़ाकर 5,000 करोड़ रुपये करने की योजना बना रही है

उत्तर प्रदेश के मुख्यमंत्री योगी आदित्यनाथ ने 25 नवंबर को कहा कि राज्य सरकार भविष्य में फिरोज़ाबाद से कांच के निर्यात को 1,000 से बढ़ाकर 5,000 करोड़ रुपये करने की योजना बना रही है, मुख्यमंत्री ने सुहागनगरी फिरोज़ाबाद में प्रबुद्धजन सम्मेलन को संबोधित करते हुए कहा, *''हमें केवल कांच की चूड़ियों और कलाकृतियों के निर्यात को बढ़ाने के लिए डिजाइनिंग के साथ-साथ आकर्षक पैकेजिंग की जरूरत है, जिसे पहले ही वैश्विक मान्यता मिल चुकी है।''*

योगी ने कहा, *''जब भी मुझे किसी विदेशी मेहमान को कुछ गिफ्ट करना होता है, तो मैं अक्सर फिरोज़ाबाद से कुछ न कुछ मंगवाता हूं।''* मुख्यमंत्री ने विभिन्न योजनाओं के हितग्राहियों को चाबियां, प्रशस्ति पत्र और चेक भी वितरित किए। सीएम ने कहा कि प्रधानमंत्री नरेंद्र मोदी के नेतृत्व में उत्तर प्रदेश ने एक नई यात्रा शुरू की है और राज्य को नए भारत के नए उ.प्र. की पहचान मिली है।

मुख्यमंत्री ने कहा कि फिरोज़ाबाद अपने कांच उत्पादों और आलू के लिए पारंपरिक रूप से प्रसिद्ध होने के बावजूद राजनीति का शिकार हो गया और समय बीतने के साथ भुला दिया गया, लेकिन डबल इंजन सरकार अपने पारंपरिक उद्योगों को पुनर्जीवित करने के लिए प्रतिबद्ध है।

(News Source: AIGMF Research Team / World Wide Web)

Mr. Raj Kumar Mittal, President UPGMS and Former President AIGMF met the Hon. Chief Minister Yogi Adityanath, Uttar Pradesh and handed over a representation, requesting to reduce the rate of VAT on Natural Gas from 10% to 5% so as to survive MSME Bangle & Glass Industries of Firozabad.

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Glass Industry Meets at Guwahati to conclude International Year of Glass celebrations in India

(Dec 9-11, Guwahati)

First ever AIGMF's Hybrid meeting as well as Executive Committee meeting was organised at Radisson Blu Hotel in Guwahati, ASSAM on Dec 10, which was hosted by North East Sillimanite Refractories, an Affiliate Member of The All India Glass Manufacturers' Federation (AIGMF).

The event saw technical presentations by the Competition Commission of India, GoI; SEFPRO/SEPR India, concluding IYoG 2022 lecture by CGCRI and release of AIGMF's 2023 calendar on 'Green as Glass'. All events were centered around International Year of Glass 2022 celebrations.

In a technical session moderated by Mr. Dave Fordham of Glass Worldwide (Honorary AIGMF member), Mr. Umesh Kumar IPS, State Resource

Person, Competition Commission of India, Government of India gave a presentation on "Competition Law for Trade Associations and Enterprises"; and Mr. Cyril Linnot and

Mr. Suraj Kumar of SEFPRO/SEPR India discussed the application of self-flow monolithics to prolong the life of glass melting furnaces in hot and cold repairs.

Mr. Umesh Kumar and Mr. Tanuj Goswami gave an Overview on the Competition Act, its objectives and functions. Inquiry, Investigation, Coverage, Powers of the Commission were also highlighted by citing suitable case records. The Presentation was well appreciated by the participating members who were around 50 comprising of glass manufacturers, affiliate members of AIGMF, special invitees etc.

A concluding lecture by Dr. K. Annapurna, Chief Scientist, Glass Division, CSIR-Central Glass & Ceramic Research Institute, summarised International Year of Glass (IYoG) activities in India. Commemorative

IYoG glass bottles specially made by AGI glaspac and HNG from the recycled glass were also awarded.

A highlight of the meeting was the release of the AIGMF calendar 2023

on the theme ‘Green as Glass’, a project centered on IYoG celebrations and featuring 2022 winners of the AIGMF’s annual contest for youth: the first-ever poem/essay writing contest on ‘Green as Glass’ that coincided with the International Youth Day.

Delegates learned about the opportunities for investment in the northeast region, including subsidies offered by the Government of Assam and the advantages of the area’s availability of natural gas, limestone, dolomite, sillimanite, mullite and corundum.

Remembering Mr. Brij Mohan Labroo, Chairman of Asahi India Glass Ltd., and Mr. Anup Kumar Dasgupta, Chairman of FGK Thermal who passed away on Nov 7 and Oct 6 respectively

Mr. Tanuj Samaddar (who lives in Assam), 2020 winner of the AIGMF's 'Drawing Competition 3.0' on the theme 'Glass Protects', addressed attendees in Guwahati and enthused about glass as "the only 100% recyclable packaging and building material."

NES hosted 2 dinner receptions on Dec 9 and 10 where cultural programme showcased the indigenous Bihu folk dance, an important part of Assamese culture. NES organised an accompanying tour to the holy city and delegates visited the Kamakhya Temple.

"Most of the glass manufacturers present in the event have been using NES products and they expressed their full satisfaction on the quality, service and performance of the products" commented Mr. Aman Gupta, Managing Partner of North East Sillimanite (a unit of NES Refractories LLP).

Glass Worldwide is the preferred International Journal of the AIGMF in association with KANCH

NES, located in Guwahati, is successfully utilising local resources and providing world class bonded refractories and monolithics to the container, float, solar, sheet, figured and opal glass sectors in India and abroad with products such as high alumina (42–99% AL_2O^3) and basic refractories including 88–98% magnesia, magnesia-zircon, magnesia-zirconia-alumina and special refractories zircon and zircon-mullite.

Select photos and presentations of the event can be downloaded from: https://aigmf.com/past-events.php

The next Executive Committee meeting is slated to be held at Jaipur on March 25 where in addition to the technical presentations, investment opportunities in the state of Rajasthan will be discussed with RICCO officials.

All Members are invited to be a part of these discussions and to celebrate 80 years of the AIGMF■

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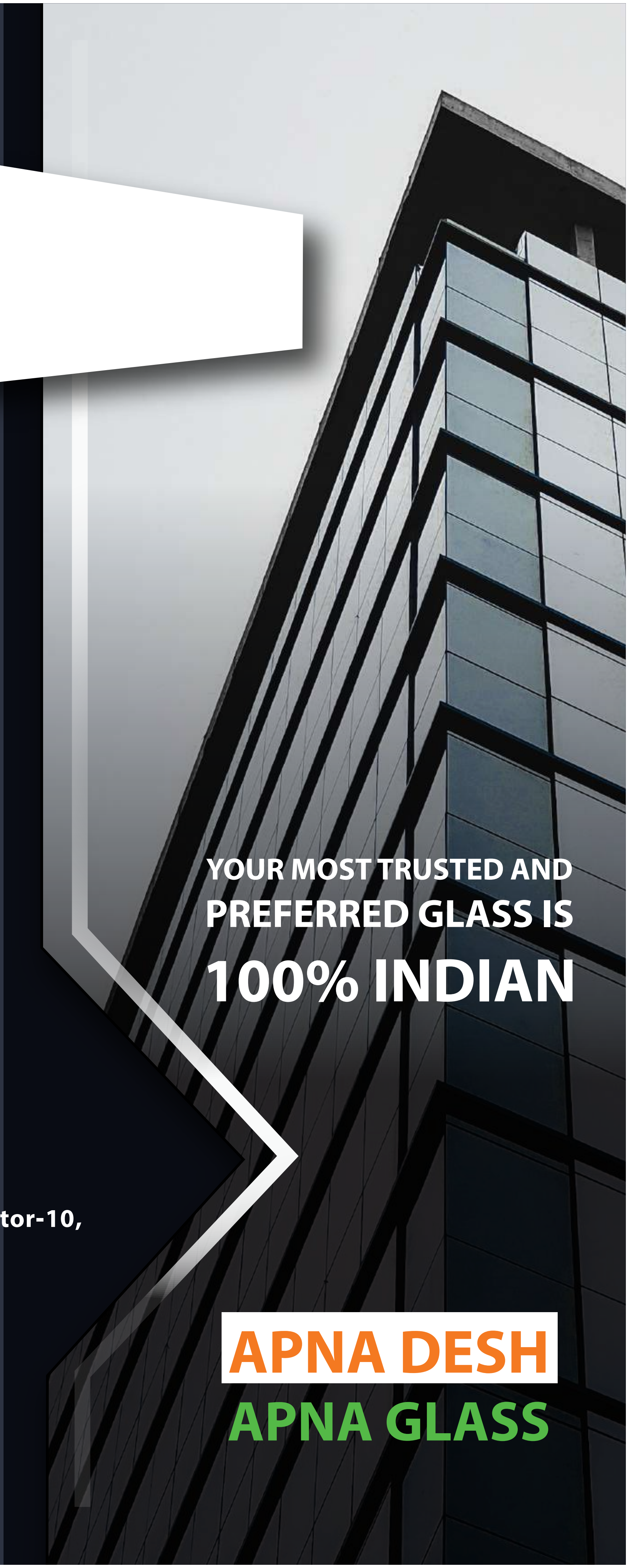

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IYoG celebration continues in India- SGT President held workshops with School & University students

(Nov 30, Delhi)

At the invitation of The All India Glass Manufactures' Federation (AIGMF), Dr. Arun Varshneya, President of Society of Glass Technology, United Kingdom and Member of the International Year of Glass IYoG 2022 held interactive sessions with the students of St. Thomas School and Delhi Technological University on Nov 30 at Delhi.

The program at the school saw a participation of around 300 students from 9th and 11th standards. The topic chosen by Prof. Varshneya was Stronger Glass Products and an Overview on IYoG (International Year of Glass 2022).

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Prof. Varshneya made the sessions very interesting over some simple experiments which created a lot of enthusiasm amongst the students. Mr. Purvish Shah, Office Bearer of AIGMF and Director of the Gopal Glass Works Ltd. in Ahmedabad, gave an overview on the Indian Glass Industry. Mr. Vinit Kapur, Secretary AIGMF highlighted the importance and need for building academic and CSR linkages for Environmental and Health reasons.

"Students were very happy to discover the magical world of glass. They learnt many facts and were eager to engage in knowing the properties, types and career prospects. We deeply thank Dr. Arun Varshneya, Mr. Purvish Shah and Mr. Vinit Kapur to help students understand that glass can transform our future and help us build a sustainable tomorrow. Thank you to the entire IYoG team for an engaging experience "Glistening Glass for a Greener Tomorrow.", St. Thomas' Girls Sr. Sec. School, Mandir Marg, New Delhi.

Prof. Varshneya is also President of Saxon Glass Technologies as

well as Professor of Glass Science & Engineering, Emeritus, at Alfred University, New York, USA.

Prof. A.S. Rao, Head, Department of Applied Physics, Delhi Technological University said that *"A Technical Talk by Prof. Arun Varshneya was organized by the Department of Applied Physics in association with The All India Glass Manufacturers' Federation on Nov 30, 2022. Prof. Varshneya interacted with our students showcasing the growing importance of glass and its popularity in packaging and building material. He has covered the topics from fundamentals to advances in glass science and technology. Discussions were carried on the further technical cooperation and research collaborations in Glass Science and Technology with the support of AIGMF. Thanks to Prof. Varshneya, Mr.*

Purvish Shah and Mr. Vinit Kapur for their presence at DTU.”

“We have received overwhelming responses from the students within a short time. Dean (Academic-PG) Prof. Rinku Sharma, Faculty Members and Research Scholars have attended the program. More than 80 members participated to make the event a grand success.”

Mr. Vinit Kapur, Secretary of the Federation gave a presentation on the most recent Indian IYoG activities involving Youth. He was in an upbeat mood to work more closely with the young minds. He said that “*students have not only shown commitment and willingness but have also contributed significantly on the relevant topics related to Health and Environment; glass and its usage in our daily lives.”*

All participating students, Teachers and Professors were given Mementoes-glass bottles with IYoG logo specially made by AGI glaspac and HNG out of the recycled glass■

Select photos and presentations are available at https://aigmf.com/past-events.php

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Museums and Society

The most frequent figures given to estimate the number of museums in the world indicate that there are some 50 to 60,000 institutions worldwide [1].

Dr. Teresa Medici

Culture in all its expressions is an essential element in improving and developing the life and the well-being of people. Among cultural institutions, museums play a strategic role in making cities and communities inclusive, safe, and sustainable.

Museums are places where tangible and intangible heritage of humanity and its environment is preserved, studied, exhibited, and communicated for the purposes of education, study and enjoyment [2]. Receiving the name from the *Museion*, "the seat of the Muses", a cultural institute active during the third century BCE in Alexandria (Egypt), modern museums were mainly created to preserve and exhibit heritage, generate cultural awareness, and promote education.

Over time, their goal has become more complex to also include training and lifelong learning, and there is growing evidence that they can contribute positively to social cohesion and integration, civic engagement, health and well-being. Supporting the architectural and social development of cities and rural areas, museums can sustain the societies to face changes. They can stimulate creativity, increase cultural diversity, regenerate the local economy, attract visitors, and generate incomes.

Even if the origin of museums is rooted in western society and culture, most communities worldwide host museums and recognize them as a tool for empowering people by providing resources for learning and developing skills, enhancing the quality of life, and offering space for sharing ideas in a safe, inclusive and accessible environment.

GLASS AND THE MUSEUM

Being not-for-profit multidisciplinary institutions open to people and embedded in the community, museums can play a strategic role in enhancing the knowledge of glass among citizens.

At the beginning of its production, more than 3500 years ago, glass was a valuable and treasured commodity, for the use of pharaohs and kings (Figure 1). Over the centuries, technological developments such as the discovery of glass blowing, combined with its invaluable properties (chemical inertness, impermeability, transparency), turned glass into one of the most exploited and versatile materials created by humankind (Figures 2-4).

Figure 1. Two-handled cosmetic jar with wide neck, core-formed. The body and the handles are of opaque dark-blue glass, the chevron decorations are in opaque white, yellow, and turquoise-blue glass. Height: 8.70 cm. Egypt, 18th Dynasty, ca 1390 BC-ca 1352 BC

Source: *British Museum*, museum number EA4741

Glass museums contribute to the preservation of glass heritage by means of acquisition, conservation, and protection of glass objects that people and communities recognize as deserving consideration and enhancement for present and future generations.

Not only dedicated organizations, but a number of institutions host glass collections of different origins and gathered for a variety of purposes. In the form of tableware, drinking glass, containers, windowpanes, personal ornaments, optical instruments, works of art, or scientific devices glass objects are spread in every kind of museum.

A variety of factors contributed to the birth of glass museums and collections.

The *Glass Cabinet* at the Rosemborg Castle in Copenhagen (DK), installed in 1714 and regarded as the first glass museum in the world, originated from a collection of precious Venetian glass gifted to the King of Denmark in 1709.

Exquisite glass vessels are exhibited in museums of decorative arts, originally created with the intention to improve

Figure 2. Seven Roman Vessels (1st century CE). Blown. Blue-green glass

Source: CMoG 77.1.2 A-G. Image licensed by *The Corning Museum of Glass*, Corning, NY (www.cmog.org) under CC BY-NC-SA 4.0

Figure 3. *Murano Glass Museum.* Diamond-point engraved and filigree glasses

Source: © Fondazione Musei Civici di Venezia - Museo del Vetro di Murano - Archivio Fotografico

the quality of national craft and industry by providing and showing selected samples of outstanding productions; good examples of this are the *Victoria and Albert Museum* in London (UK) or the Metropolitan Museum of Art in New York (US) (Figure 5).

Museums of science and technology have sections devoted to the display of scientific glass instruments that can date back to the 17th century, as the ones hosted by the *Museo Galileo* in Florence (I), or explaining the glass making process, as the *Musée des arts et métiers* in Paris (F) or the *Deutsches Museum* in Münich (D) (Figure 6).

The ancient history of glass can be traced in archaeological museums. Finds coming from archaeological excavations open a window on the use and trade of glass objects in the past. The Bronze Age glass ingots preserved in the *Museum for Underwater Archaeology* in Bodrum (TR) are evidence that the trade of glass as a raw material started very early in the history of its production: of Egyptian origin, they were found on a ship that sank off the Turkish coast, possibly on their way to the Mycenean world to be reworked.

In recent times, contemporary glass art is taking up considerable space in museum's glass galleries. By promoting national and internationals competitions and prizes, many museums contribute to the development of the artistic production considering glass as a favorite medium, encouraging and rewarding young artists for excellence. At the *European Museum of Modern Glass* in Rödental (D), the permanent exhibition includes several of the works submitted in the past for the Coburg Glass Prize contests.

Figure 4. A. Palazzo Madama, Turin. Glass gallery. Islamic glass

Source: Paloma Pastor - ICOM Glass. © Fondazione Torino Musei

To hand down the collections to future generations, conservation is a main responsibility for any museum. The work performed and the experience acquired on preservation and restoration of glass objects greatly contribute to our understanding of the materials used and of the mechanisms behind their deterioration. The results of the scientific investigation on glass supported by museums have revealed to be crucial for the correct interpretation of the collections, producing reference literature for the

Figure 5. Covered goblet with cut decoration. Clear, colourless glass, blown, cut and wheel-engraved and gilt. Including lid height: 23.50 cm. Silesia or Bohemia, about 1760

Source: *Victoria and Albert Museum*, accession number 6903&A-1860 © Victoria and Albert Museum, London

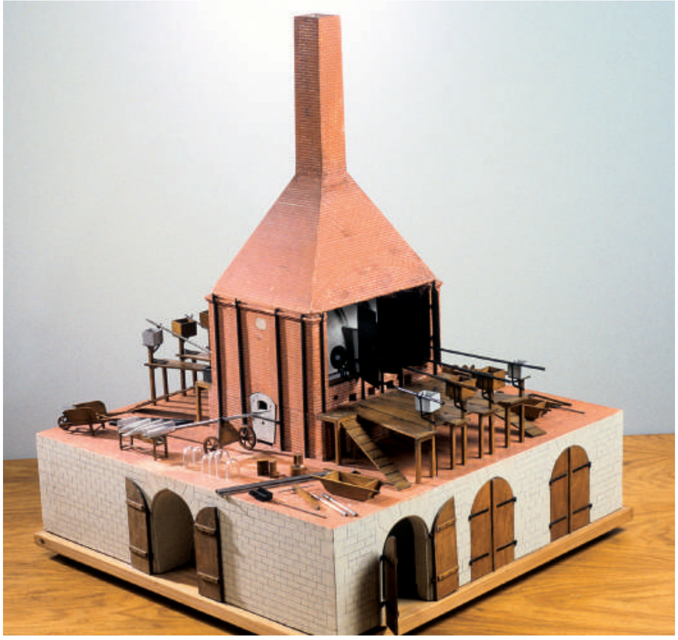

Figure 6. Model of a glass house producing cylinder glass by Appert, Mazurier & Cie, from the 1855 Paris Universal Exhibition

Source: Inv 06439. Fichier 0003280_001© *Musée des arts et métiers*, Paris / Photo Studio Cnam

Museum's libraries and archives are invaluable resources for making research on glass and glassmaking accessible to scholars and the public. Keeping a record of the museum's activities and gathering specialized collections of books and documents, they strongly support the wider research community, an important example being the *Juliette K. and Leonard S. Rakow Research Library* of *The Corning Museum of Glass,* the world's leading institution on the subject. A valuable collection of glass auction and commercial catalogues, the oldest dating from 1744, is hosted by the library of the *Musée des Arts Décoratifs* in Paris (F).

whole community of glass scholars. In museums laboratories curators and researchers can work alongside conservators and scientists, enhancing the common understanding of glass as a material, and producing state-of-art investigation. The research and conservation areas at *The Corning Museum of Glass* (Corning NY, US) pioneered the field and focused on the role of a specialized glass museum in sharing knowledge and best practices, acting as a medium between scholars, museums professionals, and the wider public (Figure 7). Robert H. Brill (1929-2021), one of the founding fathers of glass archaeometry, served as the museum's research scientist for more than 50 years. Important projects concerning the archaeometry of glass were developed in laboratories specifically created for the conservation and study of the cultural heritage preserved by museums, such as the *C2RMF - Centre de recherche et de restauration des musées de France*, whose facilities are located at the *Musée du Louvre*, Paris (F).

GLASS MUSEUMS AND THE CULTURAL LANDSCAPE

Several glass museums have been created in regions or even towns traditionally devoted to glass production as for example the *Museo del Vetro* in Murano, Venice (I) (Figure 8) or *The Corning Museum of Glass* in Corning (US) (Figure 9). The complex of buildings created in the second half of the 18th century to host the *Real Fábrica de Cristales de La Granja* at the Real Sitio de San Ildefonso (Segovia, ES) is today the home of the Fundación Centro Nacional del Vidrio (FCNV), incorporating the *Museo Tecnológico del Vidrio*.

In areas where glass manufacture has ended, museums can occupy a very special place.

The decline of the glass industry in regions with a strong tradition of glass work has contributed to the conversion of industrial history into museum exhibits and community-based museography. The musealization of abandoned glass factories collaborates in improving the regeneration of deindustrialized areas. Museums can play an important

Figure 7. Conservators Stephen Koob and Astrid van Giffen at The Corning Museum of Glass's conservation laboratory

Source: Courtesy of *The Corning Museum of Glass,* Corning, NY. © Greg Hodges

Figure 8. *Murano Glass Museum*. First floor, large central room

Source: © Fondazione Musei Civici di Venezia - Museo del Vetro di Murano - Archivio Fotografico

part in the mourning process following the demise of local industry and they can become important resources for local development. The cultural strength of these contexts can have a great effect on people, positively influencing their sense of identity. By preserving the memory of a common past and exhibiting a shared heritage, production places converted into museums help the community to reorganize itself, on the base of new economic factors. The company Glaces et Verres Spéciaux du Nord de la France, specialized in coloured window glass and better known as "Glaces de Boussois" (F), ceased traditional production in 1979. Today, former workers proudly guide the visitors around the tiny local *Musée de la Mémoire Verrière*, showing them documents, tools, and models of the past production plants and letting them know about the work and the life of the community.

Museums opened in ancient furnaces or factories can exhibit the machinery, utensils, and collections almost without removing them from the original contexts and backgrounds, increasing visitors' awareness. The *Atelier-Musée du verre* at Trélon (F) is located inside a late 19th century glasshouse with two furnaces for production of bottles and perfume flasks that were in use until 1977.

Particularly iconic are museums installed in the interior of the imposing cone-shaped glasshouses that represented a landmark in glass production areas, as the *Gernheim Glassworks* in Petershagen (D), and the *Red House Glass Cone* at Dudley (UK) (Figure 10). The symbolic force of these cone towers is so strong that modern structures destinated to host glass museums all around the world were build reproducing the shape, using glass and steel instead of brick and stone. The *Museum of Glass* at

Figure 9. Tiffany Studios Wall Case and Mosaic Column, 35 Centuries Galleries, *The Corning Museum of Glass*, Corning

Source: Courtesy of *The Corning Museum of Glass*, NY

Figure 10. *The Gernheim Glassworks* in Petershagen (D)

Source: Peter Hübbe/LWL (Industriemuseum *Westphalian State Museum of Industrial Heritage,* Dortmund)

Tacoma (WA, US) and the *GlazenHuis* at Lommel (BE) are good examples of this influence.

Glass has demonstrated the capacity to be a powerful tool for urban regeneration even in the absence of historical glasshouses. An outstanding example is offered by the plan *Glass Art City*, promoted by the City of Toyama (JP). Choosing glassmaking as a new cultural asset for the community development, the city created a system of institutions aimed at supporting talented glass artists and at spreading knowledge about glass arts and crafts. The structure is composed of the *Toyama City Institute of Glass Art* (a public educational institution), *Toyama Glass Studios*, and the *Toyama Glass Art Museum*, opened in 2015 in a breath-taking building designed by renowned architect Kengo Kuma. Great care was taken to ensure the participation of the community to this new cultural process, facilitating the interaction between the artists and the citizens by means of workshops, educational activities and glass-working experiences. As a result, Toyama is today home to the largest glass art community in Japan and the new glass culture is part of the life of the city.

THE GLASS MUSEUM AND THE PUBLIC

Being places of learning with objects, museums are crucial for dissemination, education and hands-on experience focused on glass. In every type of museum glass can be used as a medium to attract and actively engage the public.

Art, science, archaeology, history and social sciences find their meeting point in specialized glass museums and museums with collections of glass. Research carried out in museums fosters a deeper understanding of the tangible and intangible values of glass and glass objects, and the gained knowledge provides a sound basis for educational activities and communication.

Museums have plenty of stories to tell, describing raw materials and techniques needed for producing glass and glass objects through the centuries, teaching us about its origin and manufacture, and giving insight into the life of the people who created and used it. In the museum context, even the most common glass objects can provide unique learning experiences. Educational programs are designed to extend the understanding and knowledge in children and adults deepening the meaning of glass in their life. By establishing a creative relationship with schools, museums can contribute to the introduction of glass in formal and non-formal education, ensuring and promoting inclusive and equitable lifelong learning (Figure 11).

By sourcing and exhibiting objects and furniture with the aim of reconstructing the original aspect of the interior, historical house museums engage the public in glass collections in a particular way. Giving the visitors a sense of what the building's life was like when it was inhabited house museums stimulate active participation and a personal approach to the display.

Glass museums equipped with hot and cold workshops and studios can provide magical experiences for visitors and significant opportunities for creative learning (Figure 12).

The involvement of museums in glass production contributed in some cases to the reinvention and regeneration of an almost lost craft. In order to open a workshop where a visitor could observe the production of replicas of ancient glasses the *Museum of Ancient Glass* in Zadar (HR) gathered the knowledge of the last glassblowers in the country and succeeded in training young glassmakers. They are currently running a studio offering a varied and balanced set of glass making experiences.

Initiatives taken by museums have proved to be crucial in recognizing handcrafted glass production as Intangible Cultural Heritage. The manual production of glass is today recorded in the National Inventories of Intangible Cultural Heritage in countries like Finland, Germany or Spain. In 2020 "The art of glass beads in France and Italy" was inscribed on the UNESCO Representative List of the Intangible Cultural Heritage of Humanity, while a multinational application coordinated by France and involving also Germany, Finland, the Czech Republic, Hungary and Spain will be submitted in 2022 with the purpose of inscribing on the UNESCO's List the knowledge, craft techniques and skills of handmade glass production.

Figure 11. Educational activities at the *Museo Tecnológico del Vidrio*, Fundación Centro Nacional del Vidrio (Segovia, Spain)

Source: © Courtesy of Fundación Centro Nacional del Vidrio

Glassmaking activities are also tools which create inclusivity, and, in many museums, special attention is paid to community programs. The project "Tallando reflejos de vida. Mujer, vidrio y memoria" (Carving Reflections of Life - Woman, Transparency and Glass), developed by the *Museo del Vidrio* in Bogotá (CO), aimed to provide learning and training to women in a situation of social vulnerability by reactivating the glass decorative process of wheel engraving, a traditionally feminine craft.

Finally, without glass it would be impossible for museums to operate properly: thanks to technological advancements, all-glass display cases and large sheets of plate glass give museums the possibility of improving significantly the design of their exhibitions. In all of them, the essential glass is intended to be unseen.

GLASS AND ICOM

ICOM, the International Council of Museums, is a non-governmental organisation dedicated to museums and museum professionals. Founded in 1946, ICOM shared the vision of seeing in culture and education a reaction to a world war marked by extreme violence and brutality. In this vision, museums are identified as powerful tools, capable of strengthening bonds among people promoting cultural heritage worldwide and supporting citizens in building peaceful communities.

The specificity of glass in museums was soon acknowledged. Following the recommendations made by specialists of museums and collections of glass attending the 5th General Conference of ICOM in Stockholm (SE), on the 8th of July of 1959 the 6th ICOM General Assembly resolved to create an *ICOM International Committee for Museums and Collections of Glassware*, known today as *ICOM Glass IC*. The founding idea was that glass museums and glass departments would greatly benefit from close cooperation from each other. In order to further

Figure 12. Glassblower Korbinian Stöckle at work in the hot shop at *The Gernheim Glassworks* in Petershagen (D)

Source: Peter Hübbe / LWL (Industriemuseum *Westphalian State Museum of Industrial Heritage*, Dortmund)

such cooperation, an inventory of museums and public collections of glass was launched. Special attention was placed to the enhancement of a scientific approach in conservation and restoration of glass in collections.

After more than 60 years, this mandate is as relevant as ever. Recognized as an international established network of museum professionals leading with glass, ICOM Glass organizes Annual Meetings worldwide, including scientific programs and visits, fostering the sharing of knowledge, and providing collaborative opportunities among members (Figure 13). A specific Working Group devoted to Glass and Ceramics was created by ICOM-CC, the ICOM International Committee for conservation professionals, with the aim of promoting glass conservation and restoration, disseminating information and best practice.

GLASS MUSEUMS AND THE 21ST CENTURY

Museums are facing today the challenge of remaining significant in a rapidly changing world. They are driven to perform the basic functions described above while creating a more responsible relationship with their audience and communities.

The promotion of diversity and inclusion as opposed to inequality, the defence of human rights, and the accomplishment of the 2030 UN Sustainable Development Goals are issues museums are expected to address in their policies and everyday practices, sharing the vision of a peaceful, equitable, safe and sustainable world.

Is there any specific value that glass museums and collections can identify as a key factor in the process of building their new role in the society? Because glass is a unique combination of history, symbolism, technology, science, art, and everyday life it could be argued that glass museums are well equipped for this task. Speaking of glass to people is a powerful tool to increase inclusion and participation. Announcing that we are living in the Glass Age, David L. Morse and Jeffrey W. Evenson motivated their believe in this way: "The first reason is the ubiquity of glass and its central role in our day-to-day lives. We interact with glass screens on our computers and smart phones, take pictures through glass lenses, transmit and receive information via glass fibers, protect materials in glass covers and containers, and incorporate decorative and functional glass elements into our homes" (Morse & Evenson, 2016).

Glass started to impact on the world many centuries ago, and it will continue to do so. Museums will continue telling its stories.

Figure 13. ICOM Glass Meeting 2016. *Museo di Antichità*, Turin. Roman glass gallery

Source: Paloma Pastor - ICOM Glass. ©MiC - Musei Reali, *Museo di Antichità*

REFERENCES

1. *Report on the implementation of the UNESCO 2015. Recommendation on Museums & Collections*, UNESCO 2019. Available at the UNESCO Open Access Repository (http://www.unesco.org/open-access/terms-use-ccbysa-en).
2. The current ICOM definition of museum – "*A museum is a non-profit, permanent institution in the service of society and its development, open to the public, which acquires, conserves, researches, communicates and exhibits the tangible and intangible heritage of humanity and its environment for the purposes of education, study and enjoyment*" – is at the present (2022) under revision: www.icom.museum

FURTHER READING

1. Alberti, S. J. M. M. (2005): "Objects and the Museum", *Isis*, 96: 559-571.
2. Hahn, T. (1991): "In love with glass", *Museum International*, 43 (4): 202-205.
3. ICOM (2019): *Museum International* ("The Museum Definition: The Backbone of Museums"), 71.
4. Jackson, C. M. & Nicholson, P. T. (2010): "The Provenance of Some Glass Ingots from the Uluburun Shipwreck", *Journal of Archaeological Science*, 37: 295-301.
5. Morse, D. L. & Evenson, J. W. (2016): "Welcome to the Glass Age", *International Journal of Applied Glass Science*, 1-4.
6. OECD-ICOM (2019): *Culture and local development: maximising the impact. A guide for local governments, communities and museums*.
7. Simmons, J. E. (2017): *History of Museums. Encyclopedia of Library and Information Sciences*, Taylor & Francis: 1812-1823.
8. UNESCO (2015): *Recommendation concerning the Protection and Promotion of Museums and Collections, their Diversity and their Role in Society*.
9. Von Kerssenbrock-Krosigk, D. (2021): "Glass Museums", in P. Richet (editor), *Encyclopedia of Glass Science. Technology, History, and Culture*, Wiley: 1441-1455.
10. Weil, S. E. (1997): "The Museum and the Public", *Museum Management and Curatorship*, 16 (3): 257-271 ■

Membership of the Federation

Members of the Federation are classified into two categories; manufacturers of primary glass articles are enrolled as **Ordinary Members** of the Federation and suppliers to the glass industry viz., suppliers of machinery, raw materials, consultants and others connected with the glass industry are enrolled as **Affiliate Members**.

Foreign Companies supplying machinery etc., to the glass industry are also enrolled as **Affiliate Members**.

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Glass beyond Glass

Prof. Lothar Wondraczek

Understanding glasses has always had its metaphorical aspects. Among the earliest efforts to capture the nature of glass, 9th century cleric Hrbanus Maurus [1] was fascinated by visual transparency, which enabled clarity of view but also, at the same time, solid confinement. In some sense, this reflects our present understanding, where we see glasses all around us, but yet, recognize only a small fraction of the full versatility offered by this particular state of matter. Furthermore, we still do not understand the fundamental process and constraints which lead to the formation of glasses from their liquid parent states; 25 years after Phillip W. Anderson's widely cited statement, *glasses remain one of the greatest problems in solid-state physics* (P. W. Anderson, 1996).

UNIVERSALITY OF THE GLASSY STATE

Beyond their material manifestations, optical or mechanical properties, glasses are sometimes understood as representing infinity: neither truly solid nor liquid, they are assumed to flow on infinite timescales; the dependence of glass (and liquid) viscosity on temperature is one of the strongest known to physicists. Spanning more than 25 orders of magnitude, it translates into relaxation times which range from the smallest fractions of a second to centuries, millennia and aeons.

Similarly, the other characteristic of the glassy state. Spatial disorder has occupied generations of scientists in their quest for correlations, tools and physical relationships which would help to understand the macroscopic properties of glasses. Where their ordered counterparts —crystals— offered lattice periodicity and, as a consequence, powerful theory for predicting real-world behaviour, similar tools have remained elusive in the glassy world. Disorder was often associated with randomness and chaotic dynamics. However, the sheer existence of chaos has remained disputed over ideas of infinitely complex cycles which determine the dynamics of complex networks [2]. Meanwhile, we have learnt much about the structure and dynamics of the glassy state so as to assume now the existence of order in disorder, a *glass genome* yet to be deciphered [3].

None of the physico-chemical definitions of the glassy state is restricted to any particular class of materials, chemical compositions or product property. Indeed, glasses exist across all classes of chemical compounds, from the classical silicate and mineral compositions to non-oxide and metallic materials, from inorganic to organic and hybrid compounds [4]. New classes of glass are frequently discovered, for example, in metal-organic frameworks, coordination polymers and, most recently, hybrid perovskite derivatives [5]. Beyond chemical considerations, researchers work with computer or physical models comprised of hard spheres or other objects with variable interaction terms replacing chemical bonds, spin glasses evolve from magnetic disorder, and many other manifestations of glassy disorder are being explored as

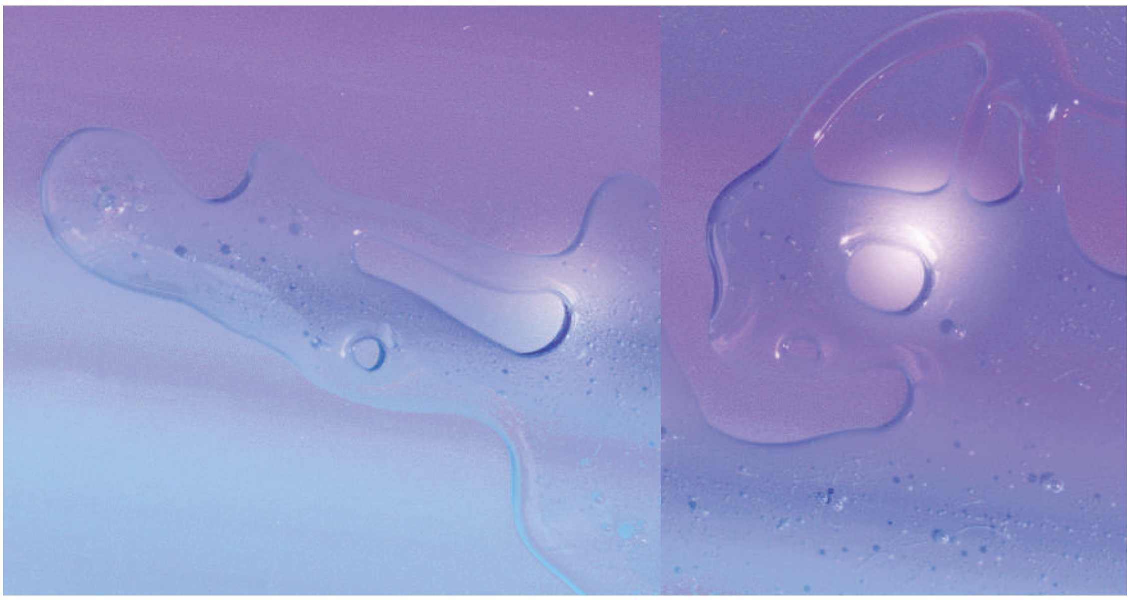


Figure 1. The glassmakers art relies on the viscosity-temperature characteristics of glass

Source: L. Wondraczek

examples for the dynamics of complex systems. Thereby, the glass itself often provides a snapshot of the liquid from which it was obtained: while a liquid is hard to observe, once its dynamics are frozen-in, a plethora of analytical tools becomes available and can give further insight on structure-property relationships.

A MATERIAL DRIVEN BY PROCESS TECHNOLOGY

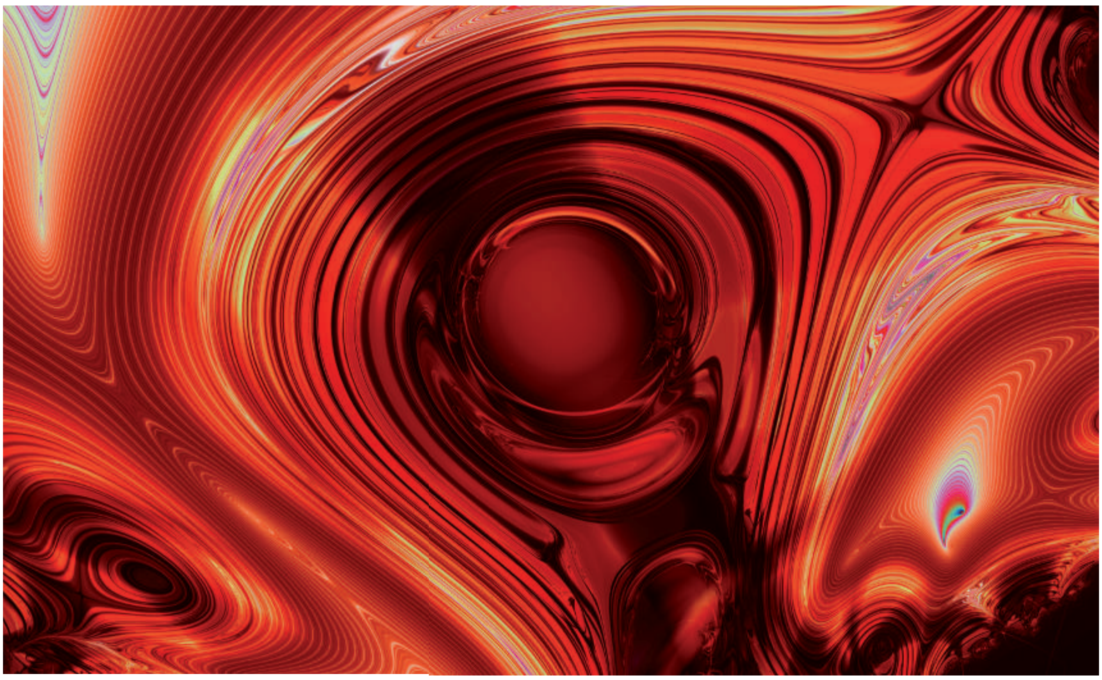
Returning to the transition from liquid to glass, it is precisely this characteristic that constitutes the practical interest and industrial importance of glasses and vitreous materials: the temperature dependence of the viscosity of glass-forming melts and their (super-cooled) liquids.

The most widespread route to create a glass is to cool down a liquid sufficiently rapidly, which leads to an increase in viscosity and, thus, a decrease in the mobility of the liquid's (atomic) constituents. This latter effect creates a kinetic barrier against assembling into the ordered crystalline state; instead a glass transition occurs at which the structural configuration of the liquid is trapped. Cooperative translational movements are no longer possible. As a consequence, the glass is a solid, but it has the molecular structure of a liquid. The reason as to why this transition occurs within such a relatively narrow temperature window remains largely unknown. However, the simple fact of tunable viscosity (using temperature) leads to the universal processability of glass-forming melts: in principle, there is a specific viscosity range for any conceivable shaping problem: fiber can be drawn, bottles be blown, filaments or microbeads be atomized, sprayed or spun, or thin sheet and even membranes be drawn, flown or floated. The technological challenge then is the development of appropriate molding machines and process chains, for example, for continuous molding at low and very low viscosity. This is not only what enabled today's glass industry, but also what makes the glass route attractive to new ranges of materials: where crystal (and often particle) processing is not efficiently or sustainably feasible in the desired shapes and geometries, glass forming procedures are sought which offer fully new opportunities (such as most recently in the world of metal-organic frameworks).

The greatest leaps in glass innovation were and are still process-related (Figure 2). They have repeatedly and in a surprising continuity led to major societal changes, from the invention of the glass blowing pipe to industrial firing systems and continuous melting units, the manufacture of flat sheet, or high-purity silica glass and the advent of optical telecommunication. And this is notwithstanding parallel developments in related fields, albeit concerning glasses in different material classes: extrusion, injection molding and the many other ways of processing polymers or, e.g., the preparation of metallic glasses which has arrived at a crossroads towards innovating future processing methodology.

ORDER IN DISORDER

The glassy nature implies their unexpectedly complex properties. For a glass of the very same chemical composition, vastly different physical properties can still be obtained as a function of the conditions at which the glass transition was conducted: many if not all properties of a glass depend on the cooling rate and pressure at which it was produced. This only adds to the effect of chemical composition and topology; in technological development, glasses have thus far largely evaded knowledge-based predictability and control of the more intricate combinations of properties such as required by modern material applications. Again, the single most important communality among all types of glass is their fundamental difference to crystalline materials: on the one hand,



like liquids, glasses exhibit high macroscopic and microscopic homogeneity. They do not consist of grains, particles or different material phases. On the other hand, they exhibit a disordered atomic structure. As recognized already by Zachariasen in 1932, structural disorder creates an excess volume over the ordered state. This is visible when comparing crystalline and glassy forms of silica, but also neatly arranged versus freely moving objects. As a result, a disordered structure becomes non-affine at a certain length scale of observation; at this length scale, it comprises spatially fluctuating properties, thus, an end to structural homogeneity. Interestingly, many of the macroscopic characteristics we usually attribute to glasses rely on exactly this interplay of long and intermediate range homogeneity on the one side, and locality on the other: the way glasses break, the way they are optically transparent or the way they transmit sound.

Entering into a new phase of glass technology, it will be a major challenge to elucidate order in disorder. Universal descriptors and quantifiers will need to be deciphered towards the predictability of non-affinity beyond individual classes of materials [6].

These will allow for a new level of material design. Processing strategies adapted to such new generations of glasses will enable a world of novel glass products, further strengthening this exciting material's indispensable role towards a sustainable future.

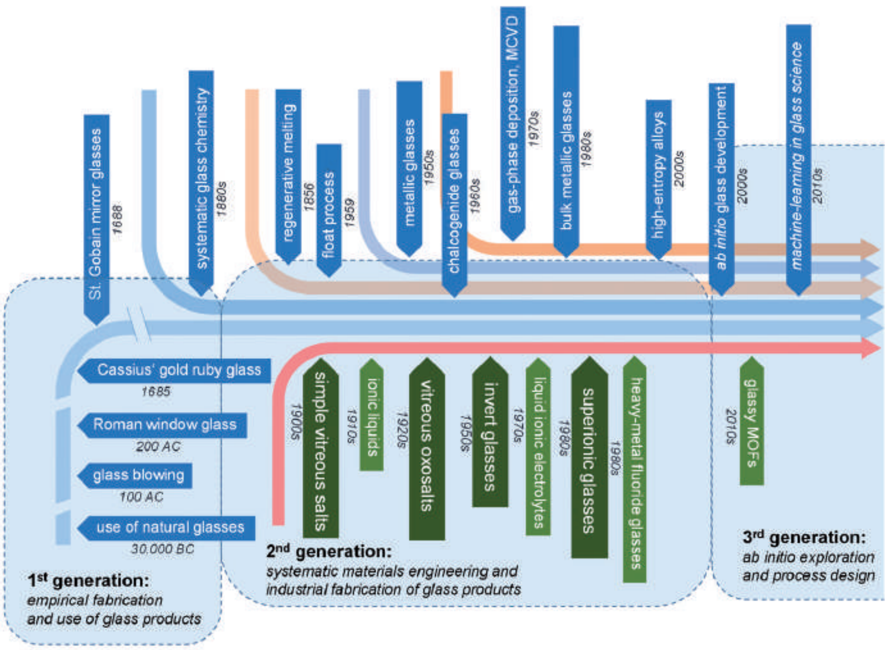


Figure 2. Glass milestones and the generations of glass technology

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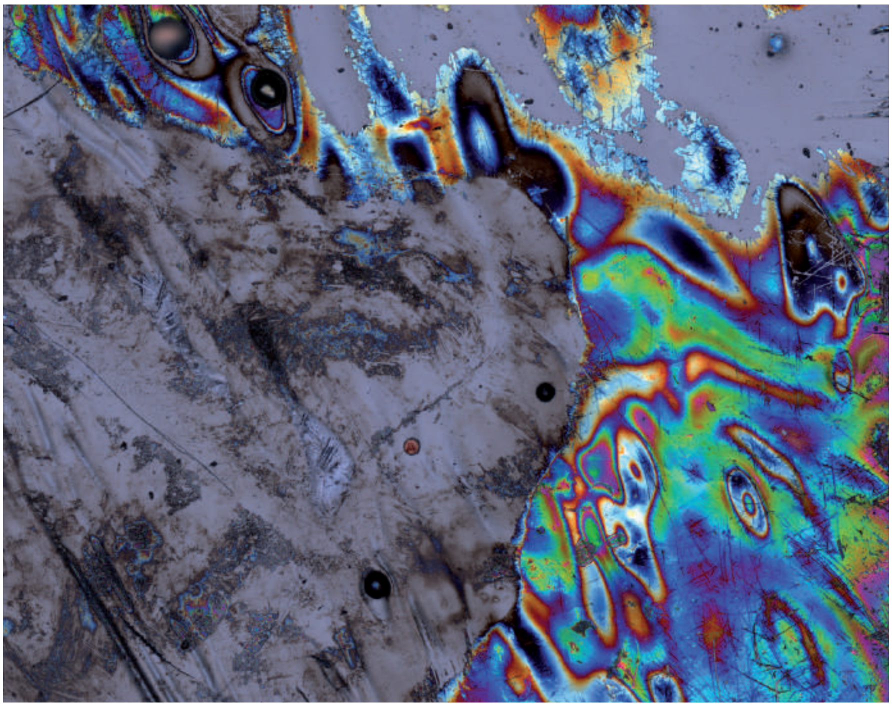

Figure 3. Order-disorder competition at a glass-like surface

Source: L. Wondraczek

REFERENCES

1. Hrabanus Maurus (780-856): *De rerum naturis*.

2. Boccaletti, S. *et al.* (2006): "Complex networks: Structure and dynamics", *Physics Reports*, 424: 175-308.

3. Mauro, J. C. *et al.* (2016): "Accelerating the Design of Functional Glasses through Modeling", *Chemistry of Materials*, 28: 4267-4277.

4. Greaves, G. N. & Sen, S. (2007): "Inorganic glasses, glass-forming liquids and amorphizing solids", *Advances in Physics*, 56: 1-166.

5. Bennett, T. D. & Horike, S. (2018): "Liquid, glass and amorphous solid states of coordination polymers and metal-organic frameworks", *Nature Reviews Materials*, 3: 431-440.

6. Lerner, E. & Bouchbinder, E. (2021): "Low-energy quasilocalized excitations in structural glasses", *The Journal of Chemical Physics*.

7. Calahoo, C. & Wondraczek, L. (2020): "Ionic glasses: Structure, properties and classification", *Journal of Non-Crystalline Solids: X*, 8: 100054 ■


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An overview of Glass Fiber Laser: Materials, Technologies and Future Challenges

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Abstract

Rare earth doped specialty glass fiber is the key component for developing high-power fiber laser suitable for many applications fields covering basic science, industry, biomedical, as well as strategic sector. Fiber Laser is almost replacing the solid-state laser system thanks to its numerous advantages like excellent beam quality, superior thermal management, small footprint to name a few. This paper is intended to provide a brief overview of material aspects, technological challenges as well as critical process optimization to develop silica glass-based high-power laser fiber. The pros and cons of conventional fabrication technology are also covered with special emphasis on future challenges towards further power scaling and the possible solution in terms of the selection of suitable glass composition, waveguide design, and modification of fabrication technology. The indigenous effort taken by CSIR-CGCRI in this particular field is also briefly described.

Keywords: High power glass fiber laser, double-clad fiber, rare-earth doping process, waveguide design, fiber fabrication, material and optical properties

INTRODUCTION

Glass has become an indispensable part of human life thanks to its myriad applications from windows, vaccine vials to communication. To commemorate the role of glass in our society, the United Nations has declared the Year 2022 as the "International Year of Glass". Specifically, optical fiber, a special type of circular waveguide, has become one of the important glass-based products without which we can't think of the present-day technology-driven society. Besides the common telecommunication application, optical glass fiber exhibits its application domain covering industrial, strategic, as well as medical sectors. Rare Earth (RE) doped inside the core of an optical fiber particularly has gained a significant research interest as a small piece of RE-doped fiber can be implemented to develop various kind of fiber-based devices like amplifier, laser, and sensors [1]. RE-doped fiber laser has gained a lot of research interest due to its multiple advantages over its solids state counterparts viz. high efficiency, superior beam quality, excellent thermal management, small footprint, etc. Accordingly, a compact fiber laser finds applications in various industrial (cutting, drilling, marking, engraving, etc.), medical (surgery, imaging, etc), strategic (directed energy weapon, LiDAR, etc.) as well as basic sciences [2]. The Fiber Laser market is expected to grow at a CAGR of 11.71% and expected to reach US$ 8.9 Bn by 2029 from its 2021 market value of US$ 3.67 Bn [3].

The first laser work was initiated by E. Snitzer [4] way back in 1961, however it took more than two decades to demonstrate its real potential again thanks to E. Snitzer who demonstrated the concept of double-clad structure in 1988 [4]. Since, then with time due to introduction of non-symmetrical double-clad structure, large mode area (LMA) design, concept of laser diode combining has lead to the development of Ytterbium (Yb)-doped fiber laser that can produce 100's of kW continuous wave (CW) output power [4]. However, research is continuing to enhance the performance of already developed laser system in terms of its long term stability, beam quality besides to enhance further power level through tweaking of waveguide

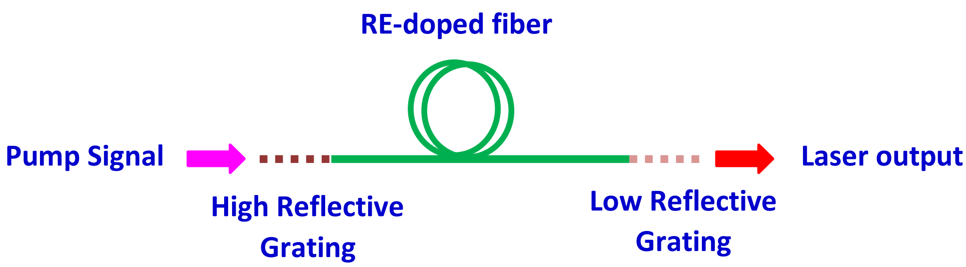

Fig. 1: Basic Fiber Laser Setup

design, core glass composition and preparation technology. In this regard the fabrication of laser fiber plays a noteworthy role as the final laser performance strongly depends on the quality of active fibers other than mechanical as well as electronic system for a packaged laser system. The article covers an overview regarding the basic requirement of waveguide design, suitable glass composition, and different fabrication process parameters. This will follow by an ephemeral discussion how the materials and design become the key factors to overcome the current limitation towards further power scaling.

The simple structure of a basic fiber laser setup is presented in Fig. 1. The setup consists of an active medium viz. RE-doped fiber, which is pumped by a solid state laser diode when the pump excited RE-ions to produce laser radiation. The active fiber is placed between two reflectors, one high reflector (HR) that maximize signal feedback within the cavity while the other one is partial reflector also known as output coupler (OC) for extracting the laser output from the cavity. The reflector either could be a mirror or fiber based grating.

Although each of the different part has their own significance, however the most important part is the active fiber which has some particular waveguide structure for efficient functioning of a fiber laser. Hence, it is essential to understand the basic waveguide prior to proceed further.

A. Waveguide requirement

Conventionally, optical fiber consists of a high refractive index (RI) core surrounded by a low refractive index cladding for light propagation following the principle of total internal reflection. This cylindrical structure of optical fiber has obvious advantages in terms of heat dissipation compared to classical solid state laser of disk or rod type [5] since optical fiber has large surface to active volume ratio. As the laser gain is dependent on the product of intensity of the pump diode and interaction length of the gain medium, the fiber geometry has clear advantages over rod or disk type laser.

The cladding-pump concept: The double clad or cladding-pump concept (Fig. 2) was introduced by Maurer in 1974 [6] and demonstrated by E. Snitzer in 1988 to overcome the limitation of output power obtained from active fiber core-pumped by commercial single as well as multimode laser diode. According to this concept, the RE-doped core is surrounded by a conventional cladding layer mainly composed of pure silica followed by low index polymer coating. The advantage of this structure is the conversion of the low-brightness high-power pump radiation to high-brightness high-power signal beam. This occurs as the pump signal introduced into the inner cladding due to total internal reflection from the outer cladding gradually get absorbed by RE-ions present in the central core over the fiber length. Thus, with increasing inner cladding diameter and the difference of RI between inner and outer cladding one can increase the brightness further.

Breaking the cladding symmetry: The double-clad concept undeniably has solved the problem of low-brightness pump source, however it is observed that significant amount of reflected rays from inner-outer cladding surface travel without interacting with RE-ions present in core in case of circular cladding. To overcome this challenge, Snitzer [7] proposed breaking of inner cladding symmetry as irregular cladding geometry forces the skew rays (meridional and helical) to follow chaotic path and thereby increasing interaction with active RE-ions to enhance pump efficiency.

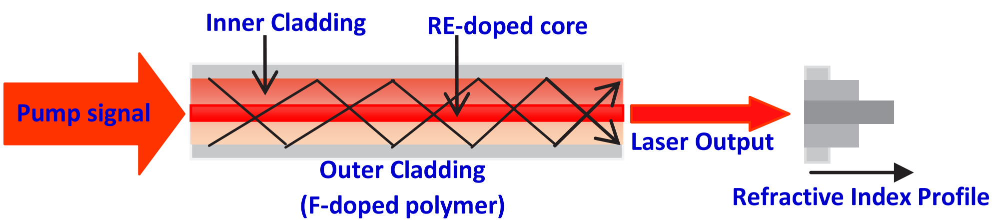

Fig. 2: Cladding pump or double-clad concept

Different, inner-cladding geometry viz. D-shaped, Double-D, rectangular, flower shaped, hexagonal, octagonal, etc. were suggested [2] and practically demonstrated by various groups (Fig. 3). Based on theoretical calculation

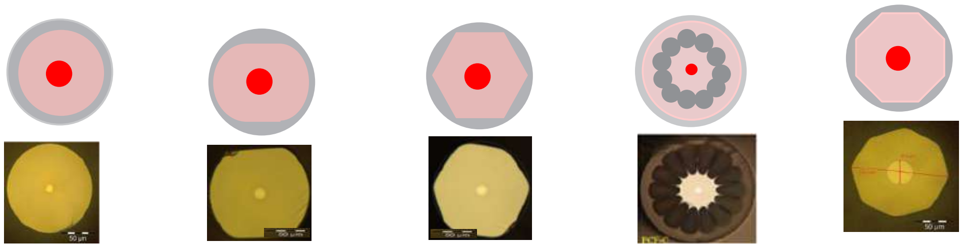

Fig. 3: Schematic of different double clad fibers and those fabricated in CSIR-CGCRI

around the world, D-shaped found to be the best, designed patented by Zellmer et al. [8]; however, to overcome the issue of splicing loss of non-circular cladding with circular passive fiber, currently octagonal inner-cladding is commercially accepted as gold standard.

Large mode area design: Considering the target to achieve the higher power, one needs to minimize the non-linear effects (stimulated Raman scattering (SRS), stimulated Brillouin scattering (SBS), etc.) which can be achieved by increasing the effective mode area that is increasing the doped core dimension. However, the large mode area (LMA) concept [9] is associated with another challenges of preserving the beam quality. This problem, additionally, makes the preform fabrication more challenging as to preserve beam quality numerical aperture (NA) need to be maintained at a lower value which limits the concentration of RE-doping and other co-dopants. Nevertheless, introduction of this LMA design has leads to the dramatic increase in continuous wave (CW) power level with nearly perfect beam quality, as presented in Fig. 4.

B. Selection of materials

Conventionally, silica is considered as the best host glass for the development of laser fiber for its multiple advantages namely low optical losses, excellent thermal stability, amazing mechanical stability, elevated radiation hardening property, low coefficient of expansion, high transparency, etc. [10]. Additionally, high vapour pressure source of high purity level ($SiCl_4$ of purity 99.9999%) is easily available for the development of high purity glass through chemical vapour deposition technique. In spite of all these advantages of silica, it poses a challenge towards the doping of RE-ions due to its compact structure along with tetra-valence which limits the RE doping level to ~ 100 ppm beyond which RE-RE clustering occurs [11]. Accordingly, silica glass structure needs to be modified by introducing some suitable co-dopants to create sufficient non-bridging oxygen (NBO) to suffice the RE-ions requirement of hexa-coordination and become an indispensable material part for RE-doped fiber. The choice of co-dopants is crucial as they have significant influence on final fiber performance such as absorption and emission characteristics, background loss, and numerical aperture (NA) of the resulting fibers.

Conventionally, Al_2O_3 is considered as the best co-dopant which either

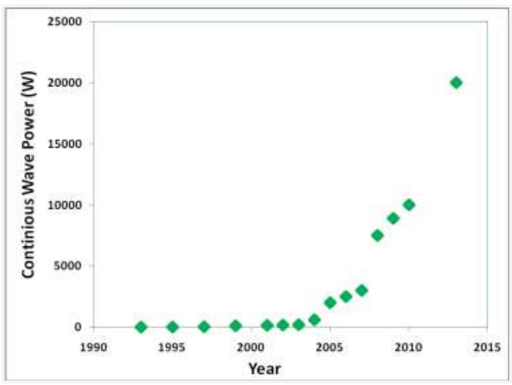

Fig. 4: Evolution of CW power with time

incorporated through SD technique dissolving suitable aluminium salts [$AlCl_3$, $Al(NO_3)_3$] in suitable solvent or through vapor phase doping using anhydrous $AlCl_3$ heated in a high temperature sublimator. The incorporation of alumina in silica glass can serve either as network former or modifier based on its tetra or hexa coordination state respectively [12]. The hexa-coordination state of Al creates sufficient NBO and thereby reduces RE-RE clustering, while the tetra-coordinate Al helps to enhance emission properties along with preferentially attract RE-ions creating a solvation shell to improve the overall fiber performance. In addition to that, alumina doping also helps to reduce the central dip formation in refractive index profile (RIP) at high temperature processing, a common problem with other well-known co-dopants. Nevertheless, the enhancement of refractive index as well as phase-separation that leads to so called "star-Like" pattern development [13] increase scattering losses pose a challenge when Al-doping goes beyond 10 mol%.

In this respect, phosphorous co-doping is also well known which conventionally incorporates through vapor phase using $POCl_3$ as starting precursor and provides larger NBO thanks to its P=O bond that enhances RE-solubility more compared to Al-doped counterpart [12]. Additionally, as RI change per mole of P_2O_5-doping (~0.6×10^{-3}) is much lower than Al_2O_3-doping (1.8×10^{-3}), for higher RE-ion doping with maintaining lower NA, P_2O_5 doping is preferred. However, like Al_2O_3-doping,

P_2O_5 doping is also associated with some challenges like central dip formation in RIP, high base loss and chances of crystallization as well as phase separation over a certain doping level.

Another, possibility researcher explored is combination of Al_2O_3- P_2O_5 doping [14] which provide advantages like higher RE-solubility, lower RI enhancement due to formation of $AlPO_4$ unit if doped maintaining 1:1 Al_2O_3:P_2O_5 ratio; although avoiding formation of triangular refractive index profile (RIP) as well as longitudinal uniformity is a challenge from fabrication standpoint. Besides these two main co-dopants (Al and P) some other less common co-dopants are also used, although their use is mainly restricted to solving other issue and beyond the scope of this article.

Among the 14 RE-elements; that are present in the 6th period of periodic table with 4f valence shell; except La and Lu, all are used to develop laser operating at different regime for different applications based on their specific emission. The different RE-ions are doped into silica glass fiber using MCVD-SD technique using suitable water-soluble RE salts or using chelate compound (viz. $RE(thd)_3$ where thd stands for tris-2,2,6.6-tetramethyl-3,5-heptanedionato) through Vapor Phase Chelate Delivery (VPCD) technique. The $RE(thd)_3$ is preferred over other chelate materials as other sources forms "Tar" like substances that hinder the flow and delivery lines become clogged making the process complicated. The three important RE-elements are Ytterbium (Yb), Erbium (Er), and Thulium (Tm) which when doped in fiber core operate at 1.06, 1.55 and 1.9 μm respectively.

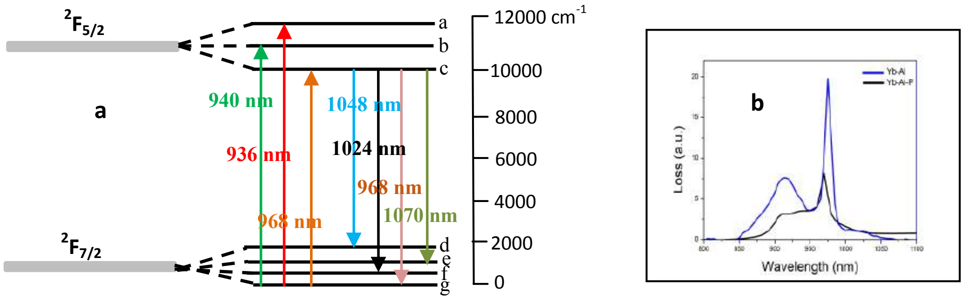

Fig.5: a) Yb^{3+} energy level diagram in silica and b) effect of host glass composition on Yb-absorption spectra

Yb-doping leads to excellent power scaling thanks to its simple two level energy states; long excited state life-time; high absorption cross-section; small quantum defects due to juxtaposition of pump and emission wavelengths; and existing high power pump sources matching with Yb pump transition [10, 15]. Yb is two level system where $^2F_{5/2}$ being the ground state, $^2F_{7/2}$ the excited state, however there are several transition possible (Fig. 5 a) thanks to "Stark-splitting" of two level. This splitting leads to characteristics Yb-emission peaks one at 976 nm which is independent of host glass composition while the other broad emission-band observed around 1000-1050 nm is strongly host-dependent (Fig. 5 b).

C. Fabrication of laser fiber

RE-doped laser fiber is conventionally fabricated using modified chemical vapour deposition (MCVD) coupled with solution doping (SD) technique [16] due to its process simplicity and ease to dope multiple RE-ions simultaneously. However, other processes are also explored namely direct nanoparticle deposition (DND) [17], sintering/melting technique [18], REPUSIL technique [19], vapor phase chelate delivery (VPCD) technique [20], etc. Irrespective of selected fabrication technique, the main steps involved in optical fiber fabrication comprised of four stages a) oxidation of suitable halide precursor at high temperature, b) deposition of obtained glass particle following the principle of thermophoresis, c) viscous sintering and collapsing of tube to obtain the preform, and d) drawing of polymer coated fiber of desire dimension.

The main challenges, during fabrication of RE-doped fiber is to achieve large core containing high RE concentration preserving NA as low as possible to support single or few-mode operation at desired wavelength (1 μm for Yb-doped fiber). To achieve, this special requirement, MCVD-SD and VPCD are two mostly adopted method. However, in order to achieve single mode propagation over a long wavelength range, photonic crystal fiber (PCF) that comprised of arrays of air holes surrounding a circular silica core is also attractive option. Theoretically, the PCF design can enhance the mode area to infinity and thus can overcome the restriction of NA limitation of RE-doped fiber core. The PCF is generally fabricated by stacking of silica capillary in a particular array surrounding the solid Yb-doped core, followed by drawing of polymer coated fiber from the stack [21]. However, problems of long length uniformity, scattering losses and splicing of PCF with conventional fibers are challenging towards practical implementation of PCF and thus here discussion is restricted to conventional solid core RE-doped fiber.

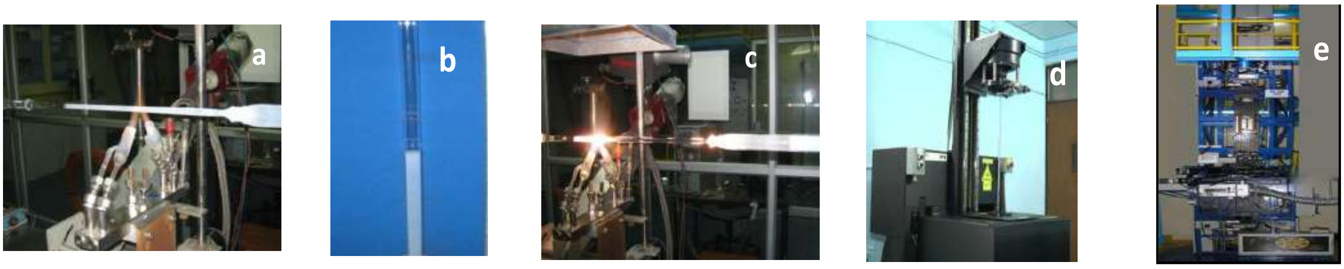

Fig. 6: Important stages of optical fiber fabrication: a) deposition of porous soot layer, b) solution doping, c) collapsing to obtain preform, d) preform analysis, e) fiber drawing

In MCVD-SD process, a porous soot layer comprised of either pure SiO_2 or mixed with P_2O_5 are deposited over a sintered cladding layer inside a high purity silica tube (F-300 grade) of desired dimension. The deposition of porous soot layer occurs when starting halide precursor ($SiCl_4$ and $POCl_3$) are oxidised at suitable temperature in presence of Oxygen gas. This soot layer is then impregnated using an aqueous/alcoholic solution comprised of $AlCl_3$ and $YbCl_3$ in requisite amount for fixed time span. The soaked layer is then dried in air, dehydrated to reduce OH-loss under Cl_2/O_2 atmosphere, sintered to a clear glassy layer and finally collapsed above 2000°C to obtain the solid rod known as preform. The important process step to develop a preform using MCVD-SD process and fiber draw technique are presented in Fig. 6. MCVD-SD process require various process parameters optimizations viz. porous soot layer composition, deposition temperature, solution composition, sintering parameters, etc. are few of them and effects of these parameters are already investigated [22-24]. Although, the MCVD-SD process is simple, nevertheless considering the non-uniform dopant distribution along the preform length, limitation related to achievable core dimension and most importantly poor process repeatability are the serious hitches of this MCVD-SD process to make laser fiber.

To overcome these challenges, VPCD technique provide a solution where RE-ions are introduced in-situ during core layer deposition and thus overcome the limitation posed by MCVD-SD process. The VPCD system consist of high temperature sublimator in addition to normal MCVD set-up for the supply of dopants like Al, Yb, etc. by heating solid precursors at suitable temperature. Al_2O_3 can be introduced in vapor phase using anhy $AlCl_3$ as solid precursor while Yb-chelate viz. $Yb(thd)_3$ as Yb-source. The performance of final fiber depends on the mother preform which in turn depends on various fabrication parameters like selected vapor phase composition, sublimator temperature, Al/Yb ratio, auxiliary burner temperature, collapsing condition, etc. which are already well documented [25,26]. Although, the VPCD process can provide much improved dopant distribution in the final fiber, the process is limited to incorporate few (2 to 3) dopants simultaneously considering the complexity of the system. Accordingly, researcher is working to develop some hybrid process to utilize the advantages of both MCVD-SD and VPCD technique for development of laser fiber.

In order to achieve, the cladding pump configuration, the mother preform need to be processed further. Based on the waveguide parameter in mother preform and the required parameter of the final target, a suitable silica tube is selected for jacketing the original preform, maintaining an optimized condition to preserve the core-clad concentricity. Next, the over-cladded perform undergo grinding to the desired shape in order to break the cladding symmetry, followed by polishing of the surface to minimize the scattering loss in the resulting fiber. Finally, from the polished shaped (hexagonal/octagonal) preform, bare fiber of cladding dimension 400±5 μm is drawn with low-RI coating.

In India, there are few companies viz. Sterlite Technologies, Aksh Optifiber Limited, HFCL Limited, etc. working on production of standard telecom cable. However, activity related to specialty optical fiber specifically RE-doped fiber is not known. In this regard, CSIR-CGCRI is the only organization working towards the development of different RE-doped laser fiber using CGCRI patented VPCD technique (Fig. 7). Various kind of laser fiber of different novel composition and waveguide structure have been developed and after basic characterization, prototype module has also been developed with good lasing efficiency (>75%). Fibers for both CW and pulsed laser application have been developed with stable power level beyond 100's of W. In this regard, CGCRI is closely working with different DRDO organizations like Centre for High Energy Systems and Sciences (CHESS), Hyderabad; Naval Physical and Oceanographic Laboratory (NPOL), Cochin; International Advanced Research Centre for Powder Metallurgy and New Materials (ARCI) Hyderabad,

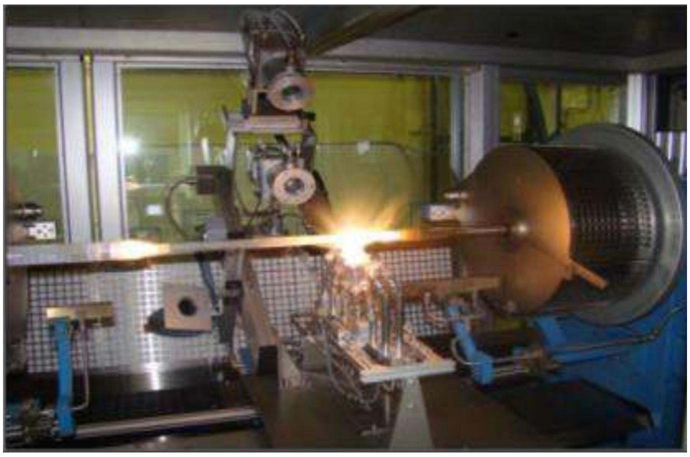

Fig. 7: MCVD-VPCD system for development of optical preform

etc. along with industrial partner like SFO Technology, Cochin; Bharat Electronics Limited (BEL), Bangalore; Aeromec Marketing Pvt. Ltd. Mumbai; etc. as per their requirement in the area of development of laser fiber and fiber based components for high power laser applications.

D. Fabrication challenges associated

The fabrication of the laser fiber needs critical optimization of different fabrication parameters in order to minimize the background loss as laser efficiency and thermal loading depends strongly on this loss factors. Accordingly, to minimize this loss the source need identification which can be broadly divided into two parts namely a) extrinsic loss that depends on the purity of starting materials, and b) intrinsic loss that originates during preform processing.

Evidently, the extrinsic loss can be minimized by selecting very high quality starting tubes, high purity silica sources and Al/RE precursor materials used during preform fabrication stage. On the other hand, intrinsic loss originates due to RE-RE clustering as a result of poor RE solubility in silica glass, phase separation of core glass at high temperature processing, scattering loss, and finally drawing induced loss due to doped RE-ions. To diminish these losses, the feasible solution is a) to select suitable co-dopants that can provide sufficient NBO to minimize RE-RE clustering; b) suitable collapsing environment to minimize the formation of point defects as well as phase separation, and c) optimized drawing condition specifically drawing temperature, drawing tension as well as UV laser power to cure the low RI polymer.

Another issue is diffusion of dopants [27] during high temperature processing that control the uniformity of RI profile as well as dopant distribution, which in turn manipulate laser performance specifically for RE-doping. This has been observed that the fluorescence lifetime fairly depends on the drawing parameter and in general the life-time decreases in case of drawn fiber compared to lifetime measured in preform sample. This decrease in lifetime is possibly due to diffusion of RE-ions during high temperature drawing to an hostile environment that leads to RE-RE clustering. To minimize this effect, one need to modify the host glass configuration in such a way that even after diffusion, the RE clustering does not occur.

An additional factor that has strong influence on UV/Vis absorption characteristics is the collapsing condition, although no such effect is observed in NIR region. The formation of Yb^{2+} in reducing environment leads to red shift of UV edge towards the Vis region and can extend up to NIR region. This leads to a significant increase of background loss that will ultimately reduce the lasing efficiency too. Thus, special care must be taken to maintain an oxidising environment during collapsing stage.

E. Problems towards further power scaling

In order to extend fiber laser application further, power scaling in terms of the average power, pulse energy and the peak power is essential. This power scaling finds several bottlenecks that needs to be overcome such as non-linear effects like Stimulated Brillion Scattering (SBS), Stimulated Raman Scattering (SRS), Photodarkening induced loss, Transverse Modal Instability (TMI), Increasing Pumping efficiency, Thermal loading issues, etc. [2,4,10]. Among the different problems mentioned, some issues are very briefly covered along with possible mitigating approaches in terms of material as well as from fiber designing view point.

Stimulated Brillion Scattering (SBS) that originate via scattering from acoustic phonon and believe to limit the optical power spectral density as well as can damage optical component. Since, SBS originate due to mismatch between the optical and acoustic field; the simplest approach is to tune the core glass composition by reducing the interaction between the optical and acoustic field. One can tune dopants profile in the core and cladding to guide the optical wave in the core while obstruct the acoustic wave. To achieve that, Al can be doped in the core that increase optical index while decreases acoustic index along with F-doping in cladding that decreases optical index while increases acoustic index. Another option is to select a core composition composed of dopants of different materials to tune the overlap of optical and acoustic wave.

Stimulated Raman Scattering (SRS) is another drawback that limits the output power, beam quality as well as the effective distance that a laser can travel. SRS appears beyond a particular power level known as SRS threshold when a significant amount of energy shifted to produce Stokes wavelength. The simplest way of controlling SRS is to enhance the effective core area and minimize the fiber length, which requires higher RE ion doping. In this regard, a triple clad design, W-type fiber design for spectral filtering are some possible fiber design that are associated with complex fabrication technology. Additionally, other techniques like introducing long-period fiber brag grating (LPFBG), chirp-tilted fiber grating (CTFBG) or photonic band gap structure could also be tried to diminish the scattering.

The "Photodarkening" (PD) is defined as temporal decay of average output power and increased losses at around 1-μm and leads to long term stability of laser system. There is various proposition regarding the origin of PD in laser fiber although the most accepted reason is the formation of defect centre viz. oxygen deficiency centre (ODC) and formation of Yb^{2+} ions. To tackle this problem, there are various techniques reported by different research group viz. highly oxidising environment during collapsing, hydrogen loading, thermal annealing, use of co-dopants like F, Ce, Y, etc. All these dopants when incorporated into the fiber core try to minimize formation of Yb^{2+}, reduces RE-RE clustering as well as increasing thermal conductivity. The detail mechanism and techniques are beyond the scope of this article. However, there are review papers available that deals with the orgin and mitigation of PD in RE-doped fibers [28].

Transverse Mode Instabilities (TMI) is a very serious issue [2] and considered the most deleterious drawback that actually leads to degradation of beam profile after a threshold output power is achieved. The beam profile is quantitatively determined by beam quality factor (M2) and defined as a ratio of beam parameter product of a particular laser in comparison to a perfectly diffraction limited Gaussian beam (M2 = 1). The particular use of laser application determines the M2 value; viz. for precise laser application like laser-weapon M2 close to 1 is favoured while for bulk material processing higher M2 (>1.5) will be more beneficial. Accordingly, based on application requirement one need to modify the waveguide design to jingle the interaction between higher order modes (HOMs) with fundamental modes (FM). Besides tuning waveguide parameters such as core/clad dimension, NA, dopant distribution profiles, some other techniques like optimization of fiber length; selection of suitable pump wavelength, pumping scheme, finding appropriate bending radius of fiber are essential. Detailed discussion regarding controlling this TMI problem is out of the scope for this article. However, it is prudent to mention some particular waveguide design that are proposed and demonstrated to tune the beam quality at high power level. In this regard, confined RE doping, graded index (GRIN) structure, depressed clad-trench fiber, are some new waveguide design and CSIR-CGCRI has already demonstrated (Fig. 8) some success stories in this regard [29-30].

CONCLUSION

In conclusion, it is evident that from inception of first demonstration of fiber laser in early 1960 with few mw of power researcher has now achieved 100s of kW CW output power by overcoming several technical and material related problems by intelligent waveguide design, appropriate selection of glass composition and improved fabrication methodology. Considering the future need of further power scaling for extended application, it is essential to overcome various bottlenecks through improved waveguide designing, search of novel composition, along with innovative fabrication routes.

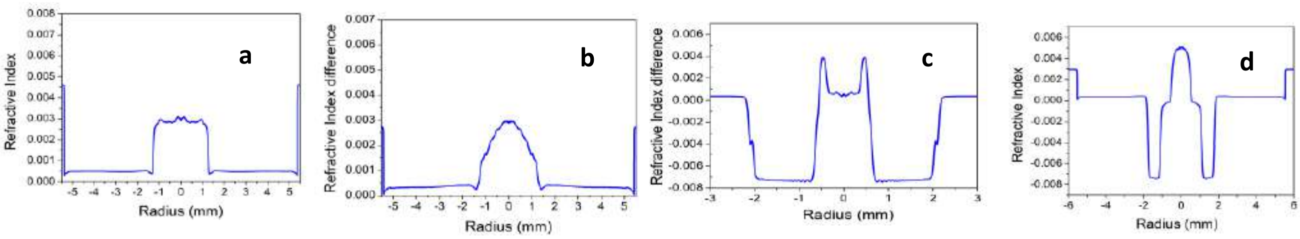

Fig. 8: Different waveguide structure fabricated at CSIR-CGCRI for overcoming various problem of power scaling; a) Confined core design, b) Graded index design, c) M-type design, d) Trench fiber

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REFERENCES

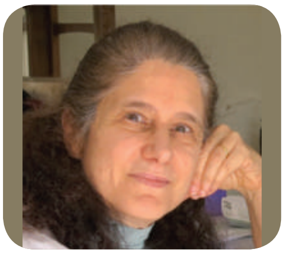
1. A. Mendez and T. F. Morse, "Specialty Optical Fibers Handbook," Academic Press, (2007).
2. M. N. Zervas and C. A. Codemard, "High Power Fiber Lasers: A Review," *IEEE J. selected Topics in Quantum Electronics*, 20(5), 0904123 (2014).
3. https://www.maximizemarketresearch.com/market-report/fiber-laser-market/13165/
4. J. Hecht, "High-Power Fiber Laser", *Optics & Photonics News*, October (2018).
5. H. R. Muller, J. Kirchhof, V. Reichel and S. Unger, "Fibers for high power lasers and amplifiers," *C. R. Physique*, 7, 154-162 (2006).
6. R. Maurer, "Optical waveguide light source," U.S. Patent 3 808 549, Apr. 30, (1974).
7. E. Snitzer, H. Po, R.P. Tuminelli, F. Hakimi, US-Patent US 4,815,079 (1989).
8. H. Zellmer, Leistungsskalierung von Faserlasern, Thesis, Universität Hannover, Germany (1996).
9. N. G. R. Boderick, H. L. Offerhaus, D. J. Richardson, R. A. Sammut, J. E. Caplan, L. Dong, "Large mode area fibers for high power applications," *Optical Fiber Technology*, 5, 185-196 (1999).
10. P. D. Dragic, M. Cavillon, and J. Ballato, "Materials for optical fiber lasers: A review," *Applied Physics Review*, 041301 (2018).
11. K. Arai, H. Namikawa, K. Kumata, Y. Ishii, H. Tanaka and I. Iida, "Fluorescence and its Nd^{3+} Concentration Dependence of Nd-Doped SiO_2 Glasses Prepared by Plasma Torch CVD," *Japanese Journal of Applied Physics*, 22, L397-L399 (1983).
12. K. Arai, H. Namikawa, K. Kumata, T. Honda, Y. Ishii, and T. Handa, "Aluminum or phosphorus co-doping effects on the fluorescence and structural properties of neodymium-doped silica glass," *Journal of Applied Physics*, 59(10), 3430-3436 (1986).
13. A. Dhar, S. Das, H. S. Maiti and R. Sen, "Fabrication of high aluminium containing rare-earth doped fiber without core-clad interface defects", *Optics Communication*, 283, 2344-2349 (2010).
14. S. Jetschke, S. Unger, A. Schwuchow, M. Leich, and J. Kirchhof, "Efficient Yb laser fibers with low photodarkening by optimization of the core composition," *Optics Express*, 16, 15540-15545 (2008).
15. J. Kirchhof, S. Unger, A. Schwuchow, S. Grimm and V. Reichel, "Materials for high power laser," J. Non-Crystalline Solids, 352, 2399-2403 (2006).
16. S. Poole, D. Payne, R. Mears, M. Fermann, R. Laming, "Fabrication and characterization of low-loss optical fibers containing rare-earth ions," *Journal of Lightwave Technology*, 4, 870-876 (1986).
17. S. Tammela, P. Kiiveri, S. Sa¨rkhilahti, M. Hotoleanu, H. Valkonen, M. Rajala, J. Kurki, K. Janka, Proc. European Conf. on Opt. Comm. 4 (2002).
18. J. Kirchhof, S. Unger, J. Kobelke, K. Schuster, K. Mo¨rl, S. Jetschke, A. Schwuchow, Proc. SPIE 5951 (2005) 595107.
19. A. Langner, G. Schötz, M. Such, T. Kayser, V. Reichel, S. Grimm, J. Kirchhof, V. Krause, and G. Rehmann, Proc. SPIE 6873, 687311 (2008).
20. R. P. Tumminelli, B. C. McCollum and E. Snitzer, *Journal of Lightwave Technology*. 8, 1680–3 (1990).
21. W. J. Wadsworth, J. C. Knight, W. H. Reeves, and P. St.J. Russell, "Yb^{3+}-doped photonic crystal fibre laser," *Electronics Letters*, 36, 1452–1453 (2000).
22. A. Dhar, M. Ch. Paul, M. Pal, A. Kr. Mondal, S. Sen, H. S. Maiti and R. Sen, "Characterization of porous core layer for controlling rare earth incorporation in optical fiber," *Optics Express*, 14(20), 9006-9015 (2006).
23. A. Dhar, M. C. Paul, M. Pal, S. K. Bhadra, H. S. Maiti and R. Sen, "An improved method of controlling rare earth incorporation in optical fiber", *Optics Communication*, 277(2), 329-334 (2007).
24. A. Dhar, A. Pal, M. Ch. Paul, P. Ray, H. S. Maiti and R. Sen, "The mechanism of rare earth incorporation in solution doping process", *Optics Express*, 16(17), 12835-12846 (2008).
25. R. Sen, M. Saha, A. Pal, M. Pal, M. Liech and J. Kobelke, "High power laser fiber fabricated through vapor phase doping of Ytterbium", *Laser Physics Letter*, 14(8), 085105 (2014).
26. M. Saha, A. Pal, M. Pal, C. Guha and R. Sen, "An optimized vapor phase doping process to fabricate large core Yb-doped fibers", *Journal of Lightwave Technology*, 33(17), 3533-3541 (2015).
27. J. Kirchhof, S. Unger, A. Schwuchow, S. Jetschke and B. Knappe, "Dopant interaction in High Power Laser Fibers", Proc. SPIE 5723, 261-272 (2005).
28. T. Sun, X. Su, Y. Zhang, H. Zhang, and Yi. Zheng, "Progress and summary of Photodarkening in Rare Earth Doped fiber", Journal of Applied Science, 11 (21), 10386 (2021).
29. N. Choudhury, N. Kr Sekhar, A. Dhar and R. Sen, "Graded-Index Ytterbium-Doped Optical Fiber Fabricated through Vapor Phase Chelate Delivery Technique", *Physics Status Solidi A-Applications and Materials Science*, 216, 1900365 (2019).
30. N. Choudhury, S. Chowdhury, S. Das Chowdhury, N. K. Sekhar, D. Jain, R. Sen and A. Dhar, "Novel Dopant Tailored Fibers Using Vapor Phase Chelate Delivery Technique", *Physics Status Solidi A-Applications and Materials Science*, 219 (1), 2100484 (2022) ■

Education! Education! Education!

HISTORY

Early glass makers guarded their know-how with considerable enthusiasm. Allegedly an early Roman recipe for making gold ruby glass was lost for many centuries because of the failure of an overcautious father on his deathbed to pass on the secrets to his son as he had in life intended to do. Inevitably history has a habit of repeating itself. Figure 1 is a ruby glass vase which was the basis of a similar but much later issue! Conversely there are reports of one of the Caesars executing a subject who had discovered how to thermally toughen glass, a process perceived as having the potential to render worthless all of the glassware in the palace treasury.

Of course, over time the approach to intellectual property became more civilized but still had the aim of keeping it in the family. For example, in the 13th century, glass making was moved from Venice to the Island of Murano partly to prevent fire in the big city but also to confine all glassmakers' families in the island, thus avoiding the spread of secrets of glass fabrication. A less confrontational approach was to offer a worthy foreman the hand of a daughter in marriage. In a local 18th century factory this created its own problems. On the death of the factory owner his wife received the estate and would allow no further factory development. She even added to her own will a codicil preventing her son-in-law from starting a new factory within 10 miles of the one she owned. A new factory, giving the foreman his own opportunity for product development, was finally built 10.3 miles away.



Prof. Ana Candida M. Rodrigues

Prof. John M. Parker

Glass artefacts have also featured in education and discovery in the Middle Ages: older monks creating artistically elaborate (illuminated) copies of the bible needed lenses to complement their eyesight; alchemists needed elaborate glass equipment for experimentation; later gentleman scientists such as Newton and Faraday demanded lenses to create telescopes that could explore the solar system.

Education for those sufficiently privileged goes back millennia. Indeed, education and knowledge are intertwined, as are knowledge and privilege. As society has become more egalitarian, education has slowly extended to a universal audience particularly during recent centuries and has taken on a wider scope. Schools, technical colleges and so on, have begun offering education for all. As knowledge has expanded in the last few centuries so specialist disciplines such as geology, chemistry and physics have grown apace and allowed people to better understand technical subjects such as glass making.

Ownership of recipe books (and technology) created a veil of secrecy in the industry that limited progress.

Nevertheless, many did record valuable insights. Among the earliest

Figure 1. A Ruby glass drinking cup. It was used in the film 'Heart of Crystal' by the German Director Werner Herzog (1976) to create the saga of a 18th-century Bavarian town, which produced Ruby Glass. When the only man who knew the secret to the production dies, the city goes into a great depression. The film illustrates how glass fabrication has been held in secret in past centuries.
Source: Ana Candida Rodrigues, UFSCar/Federal University of São Carlos & CeRTEV

records are cuneiform tablets written by the Phoenicians; in the 9^{th} century, Bede (a monk) and more recently Neri, Bontemps and many others wrote often from personal experience. In the 18^{th} century, the Diderot *Encyclopedia* published plates illustrating aspects of glass making (Figure 2).

Otto Schott, in Jena, Germany in the 19^{th} century recorded not just glass recipes but also were developing a systematic approach to the relationship between glass composition and property trends, no doubt building on the simultaneous developments taking place in chemistry.

Later, at the turn of the 20^{th} century when universal education was growing rapidly, visionaries such as Turner in the UK realized that many problems were common across the industry and were best solved by collaboration, not competition. His vision quickly extended beyond the borders of the country; he discovered like-minded people throughout the globe (in Germany, Spain, Italy, France, USA and Russia), ultimately giving birth to the International Commission on Glass which included education and 'information' among its activities as well as research programs to develop understanding.

This was also a period of change and rapid development in the Glass Industry, from pots to continuous furnaces, from hand forming to machine operation, assisted by increasing skills and deeper understanding that empowered those responsible for the factories. Travel, although not a new phenomenon, also helped to broaden their minds particularly in terms of design. For example, members of the Wood family learned the latest hand-working techniques in France before returning to the UK to run a factory in Barnsley employing several thousand workers.

Industrialization and the move away from hand blown products in turn demanded different skills from the workforce: engineers to run the forming machines and the furnaces; lab technicians to monitor quality and so on. It spawned a major industry of suppliers to provide furnace refractories, forming equipment, control gear, capping and labelling equipment, secondary fabrication such as cutting, polishing, toughening etc. Education has had to change and develop accordingly.

Of course, hand-working skills did not disappear. After the first world war, there were many disabled soldiers seeking industries where they could work and make a contribution. Turner put on classes in Sheffield on lamp-working. The skills developed were taken up by the electronics industry and ultimately underpinned the development of radio, television, communications and computing.

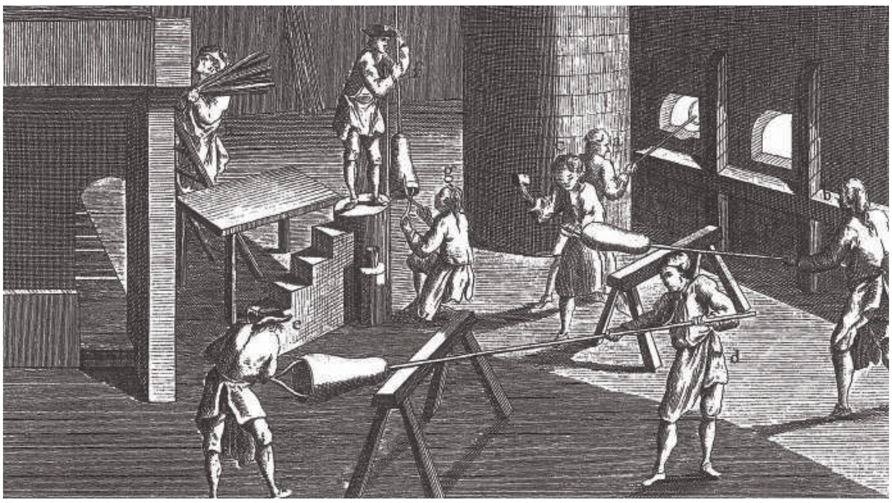


Figure 2. A glass furnace and glass blowers at work
Source: Diderot and D'Alambert's Encyclopedia (Paris: Brisson, 1751-1765)

Hand-working continues to offer valuable employment in artistic glassware. The Ruskin Mill based near Stourbridge, UK is a good example. Many with learning issues that make it difficult for them to fit into more conventional employment have discovered new opportunities. Home working is also once again a possibility and offers opportunities such as jewellery making and upcycling.

CURRENT STATUS

So, what constitutes effective Education? The dictionary definition of *Education* is: the act of imparting knowledge or skill; systematic instruction. So, there are (at least) two aspects of education, one is passing on skills and the second is the imparting knowledge. In either case a systematic approach is assumed. It's also worth considering the dictionary definition of *Learning*. This is said to be the gaining of knowledge, comprehension, or mastery of a subject through experience or study. This definition is further complicated for glass makers by the wide variety of skills and of knowledge needed within the subject of Glass Science and Engineering/Glass Technology.

EDUCATIONAL OPPORTUNITIES

So, 'Glass' lends itself to a wide range of educational opportunities. Despite its importance in our daily lives, the glass sector is relatively small compared with huge sectors such as steel and pharmaceuticals, and is one which has evolved from a multitude

Figure 3. The value of recorded knowledge (textbooks) in learning

Source: Pixabay

of small family run businesses where often education was organized by fathers for their sons, be they factory owners or master glass blowers. The industry now consists of a relatively small number of large multinational companies. Some are at least partly able to support their own education programs and the people at the top have often had a business training rather than one based on engineering skills.

All areas of the glass industry require a skilled, committed and educated workforce. Employees do need a basic appreciation of the material they are dealing with, to understand, for example, the importance of the optimum flame and batch pile distributions, the consequences of changing furnace loads, raw material characteristics, the factors affecting color, the sources and significance of seed, how the forming machines work, why fuel-to-air ratios are important and temperature measurements matter.

Larger glass companies have often created a formal relationship with a local college of education and together developed appropriate courses to maintain a stream of suitably experienced employees. These often include apprenticeship schemes which may receive government support. Pooling of resources across different disciplines within the college can also help ensure viability. In many countries apprenticeships provide an accredited and well structured, more practical environment to formalize the educational process for younger entrants.

Of course, for such schemes to attract sufficient applicants, students must be made aware of 'glass' early in their education. In the UK, links are being created and teaching material developed on subjects such as glass and recycling (Figure 4). The International Year of Glass is an opportunity to stimulate such changes and to increase the awareness of the ubiquitous presence of glass in our daily lives. In Brazil the creation of comics based on exciting developments in glass is another approach. The International Commission on Glass has used the web to make them more widely available. Only through such actions will the best students join the industry. Indeed, as the glass industry has an age distribution which is typically top heavy, such training has a role in giving glass a future.

Another educational model designed around upskilling existing employees is the one day/one week course, both on- and off-line, often available from central organizations with a commercial focus and some companies are large enough to arrange their own programs. Similar teaching can be built into the national and international conference structure. It offers opportunities for building understanding through discussion and networking. Organizations such as Celsian (Netherlands) will also travel to give targeted instruction. This model avoids the extended loss of an employee from his normal duties.

For a part of the last century when change was particularly rapid and knowledge was expanding exponentially there were undergraduate courses dedicated almost exclusively to Glass, for example in Sheffield (Department of Glass Technology, University of Sheffield, UK) and Jena (Otto-Schott-Institut für Glaschemie, Jena, Germany). They were though exceptions. Targeted education to create the 'Works Glass Technologist' has now effectively disappeared at the degree level and the subject has been subsumed within the Materials Sciences.

Shorter, specialized postgraduate courses, such as one-year masters

Figure 4. Teaching material is being developed on subjects such as glass and recycling

Source: Pixabay

degrees can complement specific training in another engineering discipline by adding a detailed appreciation of glass making. Research degrees and sponsored research programs are also needed to develop the subject, create new applications and specifically to help achieve the humanitarian goals listed elsewhere in this volume.

Recently the Glass Manufacturers Association in the USA has developed through widespread discussion an optimized syllabus for such educational models. In Australia too those involved in the flat glass processing industry have created an extensive set of online programs for workers in that field. In Brazil, in collaboration with a glass research group, a governmental institution recently created a training course to prepare technicians to work in glass plants and associated manufacturing areas. This initiative has been particularly successful, and the course has already its third cohort.

ENSURING A FUTURE

The discovery of the breakthrough process of float-glass, was based on a simple concept but involved many different steps to bring it to fruition. Since then, there have been numerous other developments in glass production, for example: in measurement and control, energy sources and efficiency, coating techniques, and specialist products such as bioglasses and mobile phone covers. All have needed people of education and imagination.

Many of the issues in running a glass furnace or processing glass have become the domain of the relevant experts within the supply chain. It remains the case that those in more responsible positions in the glass industry need a broad knowledge of many engineering disciplines, an

Figure 5. A reminder of the importance of lifelong learning

Source: Pixabay

awareness of who to talk to, and an ability to filter the information received.

The future will undoubtedly bring fresh opportunities with new markets and enhanced products. It will also come with its share of difficulties, starting with the need to ensure sustainability and a zero carbon lifestyle. People of insight, determination and energy are needed, able to access the huge databases of stored knowledge, imagine undreamt of solutions, anticipate hurdles and ensure glass takes its rightful place in our lives.

WIDER ASPECTS OF EDUCATION

Educating consumers on sustainable lifestyles depends on distributing information through standards, labelling and advertising. The concept of a "circular economy" needs to be fully comprehended so all can commit to the challenges of global change; ways to maintain a lifestyle without damaging the planet need explaining. Many organizations already do this and the IYoG2022 offers a unique and exceptional opportunity to disseminate best practices and the importance of a sustainable lifestyle.

While important in maintaining the *status quo* glass has shown a remarkable capacity to re-invent itself and help solve new problems that the world is facing be they medical, architectural, transport, communications etc. Much of this book is based around these themes. Individual enthusiasts are always needed to cope with ever changing circumstances and to push forward change.

Such progress can only be based on a sound foundation, an accurate and reliable knowledge base. That brings us to the final aspect of Education and Learning: the importance of understanding at the deepest level, which has as its starting point a process of questioning and leads to an exploration of the future.

One part of this process is the creation of textbooks, databases and even libraries which record what is known on the subject. Academia has played a vital role in developing such information sources and helping with translation into a wide range of languages. An important part of the validation of such information is a formal refereeing process. The internet and intelligent search engines allow the effective sharing of such information but can also be a way in which erroneous information becomes incorporated into the knowledge base.

Of course, the internet and textbooks offer written and much duplicated records of man's knowledge but are less effective at conveying skills, an important aspect of education. The skills of the glass blower are only passed on efficiently by demonstration and practical experience. Recordings on YouTube are a poor substitute for working with an expert. This is being recognized in advanced countries that are now keeping a record of skills that are at risk, for example the making of glass eyes is recognized as almost a lost art in the UK.

EDUCATION AND PROFESSIONAL SOCIETIES

For the general public, a quality education is the foundation for sustainable development. An inclusive education can also equip local communities with the tools required to develop innovative solutions to the world's pressing problems. A well-rounded education provides insights into the way society has coped with change over many millennia. Institutions that promote educational opportunities, also conduct basic research, organize well attended conferences, and publish advances in both glass science and engineering in highly respected journals or as highly acclaimed textbooks. At the same time their educational activities will be formally monitored and accredited by mutual comparison and often with the assistance of unbiased Professional Societies.

Glass making is highly skilled and numerous establishments offer courses a) for glass artists, b) the technicians to run factories and c) the research workers who use the unique properties of different glasses to create new products for the many challenges civilization faces. While specific data summarizing their annual economic impact are not available, it is clear a) they are located throughout the world and b) they are vital for advancing the fields of glass science, engineering and art.

Many of these activities are nurtured and chronicled by the International Commission on Glass —now in its 89th year of operation. Within ICG,

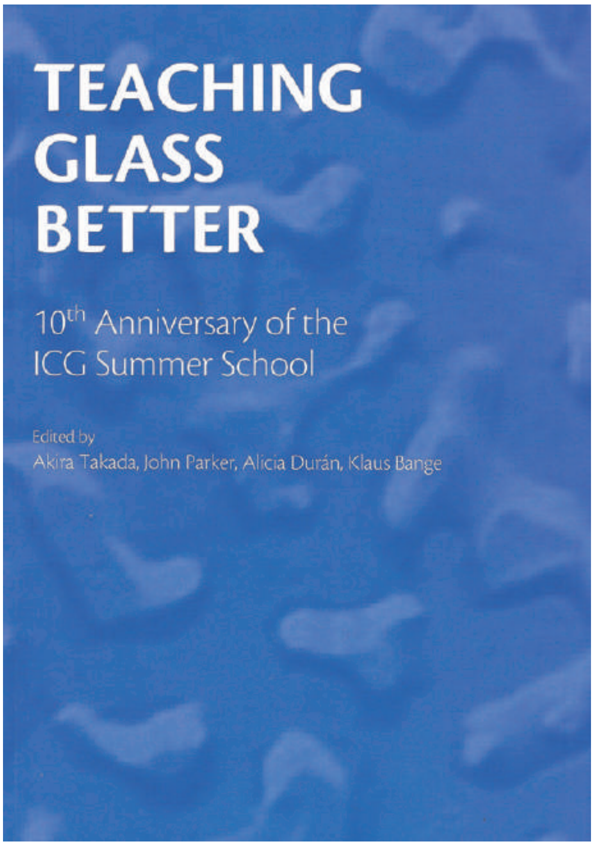


Figure 6. Cover of the ICG book 'Teaching Glass Better'

Technical Committee 23 has been specifically tasked with the mission of stimulating an understanding of glass and promoting interaction among experts in glass science and technology, art, history, and education. It has for example produced a database of textbooks and offers specialist teaching courses, often linked to conferences. Simply allowing those in education to 'rub shoulders' with each other and discuss issues also plays a vital role.

The consolidation of automated industry over the last century has reduced the numbers employed even though output has continued to rise. To help revitalize worldwide glass education in a shrinking but nevertheless vibrant jobs market, 20+ ICG Summer and Winter Schools have been held since 2009. The Montpellier Summer School reached its 11th edition in 2019 and audiences continue to grow; in 2018, to celebrate its first ten years, the volume 'Teaching Glass Better' was published (Figure 6). It summarizes the course contents and captures the historical development and philosophy of the schools, explaining the lessons learned and offering a framework for others to follow. The Wuhan ICG Winter School in China achieved its 5th anniversary in October 2019 and in the same year a new school, the NASSPM (North America Summer School on Photonic Materials) was held in Quebec with great success. India has hosted two similar events and plans another, probably in 2025. The overlapping of staff across the schools and even students has helped to propagate and stimulate best practices in teaching methods. The book *Teaching Glass Better* celebrated 10 years of ICG Summer Schools, summarizing content and capturing their historical development.

These Summer Schools for young research workers typically last a week. All have been based on similar principles, teaching key underlying subjects, which extend thinking beyond a typical undergraduate level, but then critically, encouraging a more interactive approach to build confidence in questioning conventional wisdom (Figure 7). Such exercises have also helped to break down the natural barriers that exist between pupils and their teachers and created many long-lasting friendships across national boundaries that have helped support people through the Ph.D studies (Figure 8). These schools have also been useful in passing on teaching skills among staff from different parts of the academic community. Such schools can also bring together people from very different backgrounds (e.g. the arts and sciences); the sparks so created always stimulate new thinking.

In 2021, the Montpellier Tutorial was forced online and indeed followed the example of an earlier school in India (also 2021). Considerable experience was gained on how to do this effectively but ultimately a school with face-to-face contact was seen as the preferred option.

But students respond differently to a variety of teaching styles and education is needed at different levels. Lehigh University, USA, has created a collection of hands-on demonstrations for high schools and the public. Its original version is at: https://www.lehigh.edu/imi/scied/libraryglassedu.html

Webinars and MOOCs are ways of passing on information to a large group of students but lose much of the interactive aspect that is vital for true education. The possibilities for creating such an approach for the glass community is on the agenda of TC23.

The commitment of ICG to education and outreach is also highlighted by its Youth Outreach Committee, whose goal is to organize events and mentoring programs aimed at attracting and retaining the future talents of the glass world. The idea is to provide them with the tools and the network for a successful career, where they will impact on industry and on society by developing and improving sustainable manufacturing methods and expand the applications of glass.

Of course, spotting and encouraging future talent has always been the goal

Figure 7. Group activities, giving everyone a voice, are an important part of the learning process and of developing new ideas

Source: Pixabay

of those 'at the top' but often sons, and only rarely daughters were targeted. UN GOAL 5 states that gender equality is a fundamental human right, and a foundation for a peaceful, prosperous and sustainable world. Educating companies and institutions in managing diversity, making it an engine for innovation and creativity, is the best route to a brighter future. Gender matters. Women are half of the world and must become half the glass world including education.

Nurturing exceptional talent of any gender is an important part of ensuring the future of any subject or organization. Another role that ICG and others have taken on is the award of prizes to younger members whose work demonstrates an unusual level of talent and enthusiasm. Prizes are awarded at various levels from those just starting to older members who have shown continuing excellence over many years. Even lifetime achievements are rewarded. The art world also has its competitions that promote innovative approaches and excellent workmanship. All promote the glass world.

Education is not only important at the highest levels but also for primary and secondary students, and for young technicians. Active programs targeting such groups are taking place in for example Brazil and India. We hope that a Year of Glass will encourage the wider sharing of existing practice and the stimulation of new ideas. Education is the best way to reach and instruct younger generations, raising their awareness of sustainable development goals and how to achieve them, starting from small changes in everyday life. Multiple examples need to be incorporated at every level, from elementary schools to colleges and university, to demonstrate the potential of glass in different applications and as an essential material to face the challenges of climate change and a sustainable society.

Many other national and international organizations have similar aims. ICG is in contact with the British Glaziers and GlaaS, its equivalent in Australia. Another goal of the IYoG2022 will therefore be to encourage the sharing of aspirations and to expand the scope of courses available. This will include reviews of standards and how these are maintained and even improved,

Figure 8. Students enjoying some sun during a coffee break at a Montpellier Summer School

a sharing of educational experiences across different sections, and the setting up and publicizing of a database of the courses and educational material available internationally.

SUMMARY

Smooth running of industry relies on a well-educated work force, with the appropriate skills and knowledge, experienced in how to deal practically with the problems that arise and the imagination to cope with an ever-changing world. Such skills and knowledge are learned in part on the job but are also passed on to newcomers by 'elders' in the community, and all build on the firm foundation of an appropriately tailored education. Finally, developing and maintaining formal education, to better prepare qualified staff for the glass industry and to publicize the importance of glassy materials to the general public is vital ■

Figure 9. Education, sharing our knowledge, underpins the creation of a more equal society

Source: Pixabay

FURTHER READING

1. TAKADA, A. *et al.* (2019): *Teaching Glass Better*, International Commission on Glass.
2. https://www.celsian.nl/academy
3. https://www.cmog.org/article/glassmaking-diderot-encyclopedie
4. https://www.lehigh.edu/imi/scied/libraryglassedu.html
5. https://www.gpi.org/glass-education
4. https://www.pilkington.com/en/global/about/education
5. https://www.glass.org/resources/education-training
6. https://www.bullseyeglass.com/landing-page/education.html

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Gender Equality and Diversity in the Glass World

Half of the brainpower on Earth is in the heads of women. …Today, the difficulty is to move from the acceptance of equal rights to the reality of equal opportunity. This transition will not be complete until women and men have equal opportunities for occupying position in power structures throughout the world.

---Donald J. Johnston, General Secretary OECD

Prof. Alicia Durán

Feminist economists and sociologists have developed two powerful metaphors to explain the employment situation of women. The *glass ceiling* explains the difficulty of many women to access the highest professional levels, the very low presence of women in positions of power and the lack of recognition of the work of many professional women.

The *sticky floor*, on the other hand, refers to the large numbers of women condemned to occupy the lowest ranks of the occupational pyramid: temporary, part-time, low-wage jobs, considered "unskilled", etc., a floor from which they cannot escape during their working lives and which is usually inherited from mothers to daughters [1].

The scientific world has historically mistreated women. Rosalind Franklin obtained the first X-ray image of DNA but Watson, Crick and Wilkins received the Nobel Prize. Jocelyn Bell discovered pulsars but her Ph.D thesis director was awarded with the Nobel Prize. And Marie Curie twice won the Nobel Prize, but only 3% of these prizes in medicine, physics or chemistry have been conceded to women.

The historical discrimination against women in the world of science continues to be present. On March 8, 2021 there still was only one woman for every nine men in the elite of European science. European women scientists occupy very few decision-making positions; their jobs are often evaluated more harshly; they get less funding and fewer fellowships to investigate; and their salaries are lower than those of their male colleagues.

Science, as any social phenomenon, is not isolated from the historical and socioeconomic context, and its progress is closely related to power structures and relationships: economic, political and gender. There is a general philosophy according to which creative and original work that gives rise to radical transformations is produced by men, while women are more efficient in technical tasks, in obtaining data, in putting "order" in the laboratory. This idea reflects the androcentric character of scientific-technical systems, which assume that being a scientist means being part of a masculine profession and having to overcome the supposed "disadvantages" of the female sex [2].

The European Technology Assessment Network (ETAN) report, published in 2001 by the Helsinki Group, reviewed the position of women in science and technology in Europe, concluding that the "under-representation of women threatens the goals of science in achieving excellence, as well as being wasteful and unjust" [3].

A statistical review of the women in positions in higher education, research institutes and industry shows that, despite geographical variations in systems and structures, the proportion of women in senior scientific and CEO positions is extremely small everywhere, making visible the gender segregation within the scientific field. The number of women in scientific careers shows a downward curve, with a continuous drop from the beginning of studies,

Figure 1. Old postage stamp with portrait of Marie Curie, who is best known for her work discovering polonium and radium radioactive isotopes

Source: 1967 French postage stamp commemorating the 100th anniversary of Marie Curie's birth, La Poste de France where they tend to be the majority, to the higher scales of full professor, where the proportion of men is always higher. This surprising snapshot is a constant all over Europe. This situation, known as the "*scissor graphic*", is described as a "*leaky pipeline*", where women disappear from scientific careers disproportionately and constantly, and many highly trained women are lost from science [4].

The gender imbalance in R&D institutes is similar to that of Universities. Moreover, in EU industry, the best rough estimate of the proportion of women in top positions is around 3%. In June 2019, just 33 of the Fortune 500 companies had a female CEO, 6.6%. To ignore these patterns is to accept discrimination in the sciences.

Businesses of all sizes have the same natural biases; a further phenomenon appearing in the discrimination of women is: the *glass cliff*. Frequently, when a company or institution is going through a period of crisis, women are appointed to leadership positions, when the risk of failure is highest. Extending the metaphor of the glass ceiling, the notion of the "glass cliff" refers to a danger that involves exposure to risk of falling.

A 2013 study by Alison Cook and Christy Glass [5] on CEO transitions in Fortune 500 companies over a 15 year period, found that the appointment of women CEOs traditionally followed poor company performance. To make matters worse, women CEOs are 45% more likely to be fired than their male counterparts. Who are these women CEOs replaced by? Typically, white men, a scenario dubbed "the savior effect".

Why do so many high performing women accept positions that seem almost impossible to overcome? These positions although risky, provide the opportunity to have a big impact and change the course of a company. An excellent example is Iceland. After the banking crash, Iceland's women led the rescue, determined to reinvent business and society by injecting values of openness, fairness and social responsibility. From the Prime Minister to CEOs of the two biggest crashed banks, Iceland's experience shows that giving women an equal say in how business and society are run can change the world for the better.

Figure 2. Girls sharing lectures

Source: Pixabay

Different reasons explain this discrimination. Out-dated practices characterize employment selection systems and promotion procedures in academic and industrial institutions. "*Old boys' networks*" and personal invitations to occupy posts hinder and obstruct fair and effective employment procedures. Both sexism and nepotism have been documented as interfering with the peer review process.

However, the causes of this phenomenon are more complex and do not come exclusively from male discrimination. There are also values deeply rooted in society, and of course in women themselves. The gender relations in scientific environments are still and often based on a lack of recognition from the masculine side of the intellectual capacities of women, this being used as a pretext to keep them in the margins of activity, without access to real decision sites.

The 1957 Treaty of Rome established the principle of equal treatment of men and women, and European national legislations from the 1970s and 1980s made sex discrimination illegal. However, in the twenty-first century, men and women are still segregated in sciences. This segregation is:

- Horizontal: women are clustered in certain areas of science (biology, medicine).
- Vertical: women usually constitute about half the undergraduates in many disciplines, but they are a small fraction of the professoriate.
- Contractual: men are more likely to get tenure, while women take more short-term and part-time contracts.

Key science figures described in ETAN show an extremely narrow social base in terms of age, gender and ethnic origin. White men over 50 overwhelmingly dominate senior scientific committees that award research funds, grants and prizes. The lack of women in strategic decision-making positions is not just a matter of equity and gender balance. This will inevitably affect the drawing of the scientific agenda and the decisions about investment in research areas.

The segregation and male dominance in science is far reaching and selfperpetuating, feeding back into media, education and social values cited above.

HOW TO FACE THE SEGREGATION, ARGUMENTS FOR CHANGE

Following the UN Beijing Conference on women in 1995, the ETAN report highlighted the importance of "*mainstreaming*", or *integrating gender equality*, as a main policy to be implemented in science.

A subsequent report of the Directorate-General for Research of the EU [6] confirms that the under-representation of women on decision-making scientific boards implies that the individual and collective opinions of women are less likely to be listened to in policy and decision-making processes, affecting the drawing of the research agenda. Moreover, if women scientists are not visible, they cannot serve as role models to attract and retain young women in scientific professions.

The report evaluates the data, identifies existing problems and the arguments for change, and proposes actions for advancing the position of women in research, contributing to equality and quality. The arguments in favor of having more women in research decision-making positions are abundant, from human rights and ethics to economics.

Human rights arguments

The arguments of social justice and fairness say that men and women should have equal opportunities and suffer no discrimination. Moreover, improving fairness for women improves fairness for all.

Arguments concerning diversity, quality and efficiency

Diversity increases creativity. Research activities rely heavily on creativity. Diverse research teams from varied origins are in general more open to new ideas, procedures and experiments, and are thus more innovative. Research departments in multinational companies that actively develop programs to hire and retain women (as well as ethnic minorities) throughout their careers have long recognized this [7].

Diversity increases quality [8]. The more diverse the background and experiences of the researchers, the less likely it is that research is biased, or that products target only part of the market. The closer to reality the research is, the better it can produce products that people actually need and use.

Having gender balance in research brings science closer to society by reflecting its actual composition. Gender equality facilitates the inclusion of social needs and the targeting of areas otherwise easily neglected in the research agenda.

Gender equity improves efficiency. This agrees with a new orientation of universities towards business strategies. The economic world asks for more qualified personnel as 'human capital'; starting from a lack of qualified men, it turns to women and immigrants, considering the recruitment of highly qualified female researchers as a prime policy objective, particularly in male dominated fields like engineering, and even going beyond national borders.

Gender equity increases international competitiveness. Universities and research institutions with very few female professors could lose out in international competition against partners with greater participation of women researchers, thus counting on a larger pool of talent, and the benefits of increased quality brought about by greater diversity.

BENEFITS OF MAINSTREAMING DIVERSITY IN BUSINESS

Businesses are unlikely to change their corporate cultures because doing so is "nice" or "fair" for women. They may do it if there is a compelling business reason to do so. The bottom-line reasons to achieve gender diversity in leadership are indeed compelling.

Figure 3. Protest of women attendees to the PNCS congress in Saint-Malo 2018, demanding parity in the invited talks

Figure 4. Cover of IJAGS special issue Women in Glass

Figure 5. The glass blower Olga García finishes a piece in the Real Fábrica de la Granja, Spain

Source: FCNV, La Granja, Segovia, Spain

The business case for gender diversity and inclusion affects [9] [10]:

- *Returns.* Gender diversity in leadership is strongly correlated with higher returns, profitability and share price. Diverse groups (while harder to manage) simply perform better. Companies with a higher percentage of women in executive positions have a 34% higher total return to shareholders than those that do not. Companies with the most women directors outperform those with the least return on invested capital by 26%.
- MSCI Inc. studied the financial performance of U.S. companies from 2011-2016 and found that those with at least three women on the board had median gains in return on equity 11% higher, and earnings per share 45% higher, than companies with no women directors.
- Gallup studied 800 business units from the retail and hospitality industries in 2014. They found that gender-diverse business units had better financial outcomes, including revenue and net profit, than those dominated by one gender.
- The Credit Suisse Research Institute reported that companies with at least one woman on their board outperformed the peer group by 26% over the preceding six years.
- *Talent pipeline.* To have the most skilled and talented workforce, a business must attract and retain women as well as men. Engaging as much of your workforce as possible is good business; involved employees do more and better work and are less likely to leave.
- *Women's market.* Women represent a growing portion of the customers, clients and partners of many businesses, having huge buying power. Tapping this market is crucial to business growth.

Gender matters more and more, and significant changes are glimpsed in SciTech. Indeed, women in tech are committed to staying in the industry and encouraging the next generation to follow suit [11]. Women share this commitment across different stages of their careers, from early career professionals with 1-5 years' experience (80%), experienced professionals with 10+ years' experience (83%), and re-entrants to tech —women who have returned to the industry after taking a career break (88%). These figures indicate that satisfaction of women in tech improves as they progress in the industry and is positively influencing their intent to stay. Globally, nearly nine in ten women tech professionals (89%) say they would recommend a career in the tech industry to the next generation of high school and female undergraduate students.

GLASS CEILING, STICKY FLOOR AND GLASS CLIFF IN THE WORLD OF GLASS

Women in academia, researchers and technicians, suffer most of the mentioned problems; this leads to wage gaps including in public organizations such as universities and R&D centers. The Spanish Organic Law 3/2007, for the Effective Equality of Women and Men, established the obligation of designing an Equality Plan in all public bodies and companies.

In public R&D institutions as CSIC, important progress has been achieved but important differences remain, such as:

- Higher rates of temporary employment in women in comparison to men.
- Among research staff the scissor graph (glass ceiling), remains or has even worsened in the last 10 years.
- In technical staff, women are concentrated in the lower levels and are not promoted (sticky floor).
- Although salaries are fixed, wage discrimination (wage gap) occurs through the productivity system (extended working hours, supplements for higher responsibility, etc.) derived from a deficient personal/family and work balance.

Other forms of discrimination feature widely in congresses and conferences, where the numbers of invited talks and keynote lectures are always much lower for women compared to men. Indeed, a curious demonstration was organized at the PNCS conference in 2018 in Saint-Malo, when women attendees, close to half the total, represented less than 15% of invited talks. Figure 3 shows their protest at the dinner. Something is moving in the glass world.

To improve the visibility of women it is worth citing the special issue on Women in Glass published by the International Journal of Applied Glass Science (IJAGS). The issue highlights a group of outstanding women researchers who are developing their careers in academia, government laboratories and industry in 12 different countries and across a wide range of topics related to glass (Figure 4).

Another interesting issue is that the job of glassblower, an eminent and nearly exclusively masculine profession, is becoming feminized and many women blowers are learning the trade (Figure 5). This impacted on a Spanish initiative to nominate glass-blowing as a Spanish cultural heritage, intending to preserve a centennial skill worthy of support and protection. Contacts are in progress with other nations to propose that UNESCO should nominate glass-blowing as a World Heritage of Humanity.

The situation is also moving in glass companies. Although the women in CEO and Board positions of multinational glass companies are around 10%, women's networks are emerging to promote gender equality and diversity. Saint-Gobain, Schott and Corning are good examples with programs for managing diversity and gender equality. And many SME's workforces are becoming more and more feminine (Figure 6).

A common view focuses on the necessity to revamp the image of the glass industry as an employer interested in attracting and retaining the next generation of young leaders. As Dr. Diane Nicklas declares [12] "it is crucial to shape global and diverse teams; the key is the combination of 'technology' and 'people'. The Glass industry clearly lacks gender diversity and it's difficult to find many women in leadership functions. However, it is difficult to find many women in junior positions either, which means that the problem of diversity will continue to exist. We face the challenge of attracting an entire new generation. At first glance, no heavy industry nowadays is appealing to the young generation. We are neither exciting, nor techy, nor cool in their eyes. Their interests focus on the environment, sustainability, networking & culture, innovation, digitalization, high-end technology, and working for purpose-oriented organizations.

Women in a very natural way bring other skills to those found in a team composed exclusively of men. Diversity has proven to be an essential

Figure 6. Gemma Martini (in black, second row), CEO of Vitrum Glass Group, based in British Columbia, with the all-women Insulating Glass Unit assembly team

Source: Vitrum Glass Group

key success factor for teams and companies. Further benefits could reinforce the glass industry if an additional dimension of diversity were included, namely ‘cultural diversity’, even more important if the glass company serves customers at an international, if not global level.

Figure 7. Education of girls is the key to improve diversity and gender equality

Source: Pixabay

As explained by Chiara Corazza [13], Science, Technology, Engineering and Mathematics (STEM) account for “70% of the most in-demand skills”, but women account for only 24% of professionals working in STEM roles worldwide, only 35% of students and only 1 in 5 graduates across Europe.

CGénial Foundation, partnered by Saint-Gobain is working to implement some practical ideas that promote gender diversity and female leadership in STEM careers, including glass companies [14].

- *Promote inspirational careers for women*, breaking preconceptions by bringing students face-to-face with the scientific community. These out-of-school interactions allow girls to associate themselves with STEM opportunities by meeting role models and hearing about inspirational career journeys.
- *Set quotas and quantified targets for gender inclusivity in science and technology careers*: “a quantified target of 40% representation by girls in public and private sector STEM universities and graduate schools by 2025, backed by financial incentives conditional on progress towards this goal” is recommended. Another option is to impose a 40% membership quota for women on corporate executive and management committees.
- *Make the move from STEM to STEAM*. Recently a new acronym is emerging: STEAM. The addition of the letter A refers to Arts, and to the wider issues around not only creativity, but also social and societal commitment. Promoted by UNESCO, the STEAM method is an effective way of attracting women into scientific careers using an interdisciplinary approach.
- *Develop STEM networks for women*. WiT (Women in Tech), Réseaux Industrielles and WomenTech Network in the USA… In the corporate world, women are coming together and engaging in initiatives to raise awareness of issues around gender diversity in STEM careers with the goal of moving beyond preconceived ideas.
- *Raise teacher awareness of what STEM careers really are*. More and more engineering, IT and other major companies are hosting visits to production facilities and/or R&D departments to raise school awareness of corporate culture. These bridges between industry and schools encourage interaction and help deconstruct certain received wisdom about STEM careers, at the same time as highlighting the associated challenges, particularly in terms of recruitment and gender diversity.
- *Learn to code at an early age*. It’s crucial to develop computer science and coding in schools. French projects as well as approaches in the UK and Canada promote collective intelligence and creativity in ways that exclude any suggestion of gender specificity.
- *Ensure gender diversity in AI development teams*. Algorithms are biased. The fact is that men write the vast majority of these lines of code that are increasingly structuring our world. Indeed, only 15% of all the data scientists in the world are women. It’s a lack of diversity that is having serious consequences. Gender diversity in AI development is essential if we are to develop new gender-neutral technologies.

These new views on diversity aim to answer a key question: *Can a system that ignores half of the labor force be successful and economically efficient?*

To break the current situation, it is essential to change radically the governance bodies of companies, incorporating diversity as a key factor in employment policies. The role of team leaders is crucial; they must be able to create an atmosphere that encourages people to share different perspectives, guiding groups to consider different opinions and discussing them instead of simply opposing them [15].

Moreover, to go beyond the surface is essential. Encouraging companies to apply diversity does not merely mean hiring women and people from different countries! It means recruiting individuals with shared professional values whilst possibly having different perspectives. Promoting education in companies and platforms to learn how to manage diversity and make it an engine for innovation and creativity is the best way to build a brighter, more diverse future.

The necessary changes should focus on advancing [14]:

- *from inertia to awareness and commitment:* a sincere commitment is necessary, particularly among leaders in science and industry, with the goal of equality —for the benefit of quality,
- *from imbalance to balance:* a reasonable gender balance (e.g. 40:60) with suitable steps should be made mandatory in decision-making bodies,
- *from opacity to transparency:* transparent procedures should be implemented by the sci-tech community, and the criteria, success rates and evaluation reports must be made public,
- *from inequality to quality:* with measures to systematically introduce the gender perspective in human resource development and in training decision-makers and eradicating gender bias in research, recruitment and promotion procedures. There can be no quality without equality.
- *from complacency to urgency:* the glass world needs women and the young. We must act now.

Figure 8. Woman working in a glass factory modelling hot glass

Source: iStock / Getty Images Plus

A FEW BUT RELEVANT CONCLUSIONS

The limits to the participation of women in sci-tech are not professional limits, but social limits; limits that derive from a sexist educational model, which forces women who decide to work in science to identify themselves with models that pretend to be neutral but are definitely masculine [16].

In addition to implementing diversity and mainstreaming gender policies, the contradictions generated between quality and professional value on the one hand, and expectations and social images of women on the other must be overcome. This means betting on outputs where the logic of equality nurtures and supports the logic of difference, a commitment to building another science from women themselves, another way of approaching scientific work —already proposed by *Science or Nature*— which combines vital options and does not require a choice between professional and personal life.

Gender equality is a task that transcends the world of research and industry because it must begin with the transformation of education into a co-educational project, with teachings that transmit transformative knowledge, that recognize and incorporate the social relations of sex and constitute a stage towards a more complete culture, made by men and women. This is the challenge because this is the future.

REFERENCES

1. Durán, A. (2019): "Breaking the glass ceiling", chapter of the book published by Nippon Electric Glass for its 70th anniversary.
2. Arditti, R. (1982): "Feminism and Science", *The Changing Experience of Women*, The Open University.
3. European (2000): *Science Policies in the European Union. Promoting Excellence through Mainstreaming Gender Equality*, ETAN Expert Working Group on Women and Science.
4. Etzkowitz, H. *et al.* (1994): "The Paradox of Critical Mass for Women in Science", *Science*, 266: 51-54.
5. Cook, A. & Glass, C. (2014): "Above the glass ceiling: When are women and racial/ethnic minorities promoted to CEO?", *Strategic Management Journal*, 35 (7): 1080-1089.
6. European Research Area (2008): *Mapping the maze: Getting more women to the top in research.*
7. European Commission (2006): *Women in Science and Technology. The Business Perspective*, EUR 22065 EN: 19-25.
8. Barres, B. A. (2006): "Does Gender Matter?", *Nature*.
9. Turner, C. (2017): *The Business Case for Gender Diversity*, Difference WORKS, LLC.
10. Solomon, C. (2018): "Unlocking the Business Benefits of Gender Diversity", *Culture Wizard*.
11. Booking.Com Research (2018): "More than Four in Five Women in Tech Globally Intend to Stay in the Industry, and Are Taking the Lead Towards Achieving Gender Parity".
12. https://www.glass-international.com/features/a-female-career-in-the-global-glass-industry
13. Corazza, C. (2020): "Women at the heart of the economy", Women's Forum for the Economy & Society.
14. https://www.saint-gobain.com/en/magazine/stories/7-practical-ideas-greater-gender-diversity-stem-careers
15. Ameli, I. (2018): "How Diversity can be an Engine of Creativity and Innovation", Twinkle Association, Communication and Marketing Professional Studying Master of Global and Transnational Sociology at University of Tampere.
16. Durán, A. (2002): "Cambiar a las mujeres o cambiar la ciencia?", *Arbor* ■

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We want to Measure Directly in the Forming Process

INTERVIEW: Dr. Michael Kellner, Development Engineer at Heye International, talks about digitisation, emissions and artificial intelligence.

Obernkirchen. Dr. Michael Kellner was born in Jena and has already come into contact with glass as a student through an internship at Schott Glas. "Glass - that's what it exactly should be" he says in retrospect, having studied building materials and process engineering with a focus on glass in Weimar. As early as 1986, he was involved with the first image processing cameras and their use for inspecting glass. "The theory was there, but the technology was not yet powerful enough for the glass industry," he says. During his doctorate on automation and image processing technology in glass production, Michael Kellner began working at Schott Glas. After the doctorate, he started as a trainee at the former company Heye-Glas, a very innovative, medium-sized enterprise. Initially, he was the link between production and development for introducing automation solutions in glass production. In 1992, he was responsible for testing the first image processing applications based on image processors at Heye, and shortly afterwards he began to develop PC-based image processing solutions. "Experts at the time thought that image processing could never work with a PC," says Kellner. "What a mistake". The "process engineer" with a doctorate leaves the company in 2000, but returns to Heye in 2006 as head of development. Since 2019, he has been responsible for the development of digital systems.

DIGITISATION AND INDUSTRY 4.0 ARE CURRENTLY MAJOR TOPICS. SINCE WHEN HAVE YOU BEEN DEALING WITH IT?

DR. MICHAEL KELLNER: Digitisation is not a new field at Heye. At the beginning of the 1990s, we introduced a PC-parameterizable, electronic timing system for controlling the IS-machines and the Hot End reject system, including the evaluation of pushing glass containers from the dead plate onto the machine conveyor by means of pushers. The complete Hot End process was converted to servo technology, i.e. from gob forming to ware handling. This was a huge step into the future, as the motion sequences were now matched and followed by the feedback generators according to the given motion curves. Shortly afterwards, the first servo motors were also used in the IS-machine to make critical process sequences reproducible and to avoid container defects. An important component in light glass production is certainly the introduction of the Heye Process Control, which digitally records and visualizes the pressing process by recording the plunger positions.

In 1998, Heye worked on a Hot End gob camera for recording the cut of gobs. But the resolution of the cameras and the performance of the PCs was not sufficient enough. Nevertheless, the experiences gained were extremely important in order to build up the skills for the following years. When the first grabber cards were available, the new Terra computers were bought and a camera-based mould number reader and a camera-based sealing surface tester were developed.

WHAT IS THE STATE OF AFFAIRS AT HEYE INTERNATIONAL?

We have converted complete machine platforms because the market has tended to triple and quadruple gob operation. Consequently, we made all the Hot End equipment "fit for the future". Today we offer the complete technology platform for all applications. We are on the right track. The further development of sensors and actuators has created new opportunities. Since the introduction of industry 4.0, we are raising the bar higher and higher. For example, the new IS-machine, namely the "Heye SpeedLine" we have developed. The SpeedLine IS-machine is the first machine that is fully bus capable.

The next development goal was to create areas in the IS-machine where sensors, actuators, the necessary cables and the processor technology could be installed safely and reliably. Safe and reliable means, in this context, protection against heat, oils, oil vapours, water, water vapour, dirt and glass. We have succeeded very well with the SpeedLine because we

Fig. 1: Heye SpeedLine IS machine

have conceived the design differently. The cable routing was first designed and it was tested, where the sensors must be mounted and how we can technically protect them to ensure long-term stability. Operating sensors without failure in a 1,000° C hot environment is not so easy. Thanks to the bus system, all systems in the machine are networked together and a large number of sensors can be managed. This naturally brings with it new possibilities and products, for example the intelligent lubrication interval control - the "Heye Multi-Circuit Central Lubrication" - which significantly saves oil and increases the lifetime of the components. Also the inline measurement of pressures and temperatures of the equipment should only be mentioned here.

With this machine, we have taken a giant step into digitisation. There is now a "Communication Tower" that combines all network components, computers and servers in one cabinet. The components are interconnected and communicate with each other. SpeedLine is a platform technology in which components such as robots or measuring and control systems can be integrated very easily. Via the Communication Tower there is also a gateway to the outside, i.e. to the customer. The Application Programmable Interface "Heye SmartLink" provides the customer with the data of the manufacturing process for individual data analysis.

DO YOU DO EVERYTHING YOURSELF AT HEYE? FOR EXAMPLE, PROGRAMMING?

Most of the software is developed by us, especially in the key technical areas. The hollow glass industry is a relatively small and very special market segment. It is difficult to explain the processes to external companies. There are a few components that we buy, such as sensors, for example. However, the suppliers then work for the glass industry in the long term and are therefore aware of the requirements.

THE REDUCTION OF CO_2 EMISSIONS IS A FIELD THAT WILL ACCOMPANY US MORE THAN EVER IN THE COMING YEARS. WHAT CONTRIBUTION CAN THE CONTAINER GLASS INDUSTRY MAKE?

It is probably the most topical issue at the moment: CO_2 footprint or decarbonisation. If you look at the side of energy consumption and leave the compensation models aside, then it is essentially about the sensible use of energy and the avoidance of energy waste.

For us as a machine manufacturer, two different directions are relevant when it comes to emissions. On the one hand, it is a matter of minimizing losses, which means producing as much as 100 per cent of the glass bottles possibly without defects. Then you don't have to throw away glass bottles, don't waste the energy needed to make them and have a better CO_2 footprint.

On the other hand, the focus is on equipment availability. It is best to operate the machine 24/7 and produce glass bottles without any defects. This also includes minimized job change times.

To avoid emissions, it is important that errors are found and eliminated as soon as possible. This is why it is so important to reduce the gap between Cold End information gathering and Hot End information processing. To increase efficiency, it is necessary to get significant improvement in equipment availability and in yield by reducing transport and quality losses.

Efficiency increase and CO_2 reduction are therefore closely related.

THEN, IDEALLY, THE MEASUREMENTS WOULD HAVE TO TAKE PLACE AT THE HOT END?

Exactly! This is not so easy, however, because many of these measurements are contacting measurements. And when I contact a hot bottle with a measuring tool, it deforms and becomes unusable. We still do not have a solution to how it might work to turn a hot bottle and, for example, to measure the wall thickness. That is not realistic at the moment.

Today, we want to measure the parameters of the forming process directly and keep them constant within narrow limits. We use infrared cameras at the Hot End to identify deviations in the process more quickly and, above all, not to exceed or fall below the limits and to take countermeasures immediately. This technology is called "Hot End Closed Loop". Ideally, non-contact sensors control and regulate the process.

WHICH CONTROL LOOPS DO YOU MEAN?

Different sensors are also used at different locations for the different process sections. They are then used to influence parameters of the gob, the parison or the bottle.

If you start with the gob forming, you use a gob camera to adjust and control the gob shape and gob weight. Also, the gob temperatures can be measured to influence the spout temperature in the feeder. On the blank side, the gob delivery into the blank mould can be detected and adjusted. The tool temperatures on the blank side (blank mould, neck ring and plunger) can also be measured and controlled. Infrared cameras on the machine conveyor are already frequently used today to measure wall thickness distribution and detect global errors. Optical cameras are planned on the machine conveyor for measuring and controlling the container geometry and for detecting glass defects.

AND AT THE COLD END?

The manufacturing process is completed when the glass container passes the annealing lehr. The Cold End does not deal with controlling the process. However, what should be mentioned, is to check automatically whether the inspection machines are set correctly by using sample containers. However, downstream

Fig. 2: SmartLine 2 Cold End inspection machine

processes, such as printing or surface treatments for increasing the strength, can also be measured and controlled.

WHAT ROLE DO THE WEIGHT AND SHAPE OF THE GLASS BOTTLE PLAY?

In the 1990s, a price war broke out for disposable packaging. In order to save on raw material, energy and transport costs and also to reduce the charges to the dual system for disposable bulk items, projects have been launched to reduce the weight of glass containers – that means, to produce with thinner wall thickness. Heye has a very big advantage with its experience from H1-2 technology and was able to transfer this to IS-machine technology. A relic of these times is the famous Paderborner beer bottle. It was shown that the shape has an immense influence on the weight of the container while maintaining its strength. Today, a compromise is sought between an individual bottle shape, volume and weight with sufficient strength. If we want to become more ecological, then we will have to compromise on the individual bottle shape in favour of the container weight.

Many machine components and HI products, which were already developed for light glass technology at the time, are now standard in industry. Starting with the "Process Control", through axial cooling and hot end transport – all of them components that can be used with know-how for the production of lightweight containers.

LIGHTWEIGHT GLASS PRODUCTION SEEMS TO BE A BIG CHALLENGE.

The characteristic of simple light glass is that it breaks very quickly. You can fix this problem with thermal or chemical post-processing, but it will increase unit costs. No one would probably pay a deposit of several Euros for a gorilla milk glass bottle. For the future, a technology must be developed that is based on the current hollow glass production and is efficient. Anyone who manages to increase and maintain the glass surface strength in the production of lightweight glass will be at the forefront in the future.

WHERE DO YOU SEE FURTHER EMISSION SAVINGS POTENTIAL?

I see the big emission savings in the glass industry globally in the recycling of cullet from the market (waste glass collection and processing), because for a glass bottle production from cullet, much less energy is needed than for a production from raw materials. Energy savings through heat recovery from the forming processes and in the annealing lehr have further potential. The ecological approach follows the economic approach: If you save

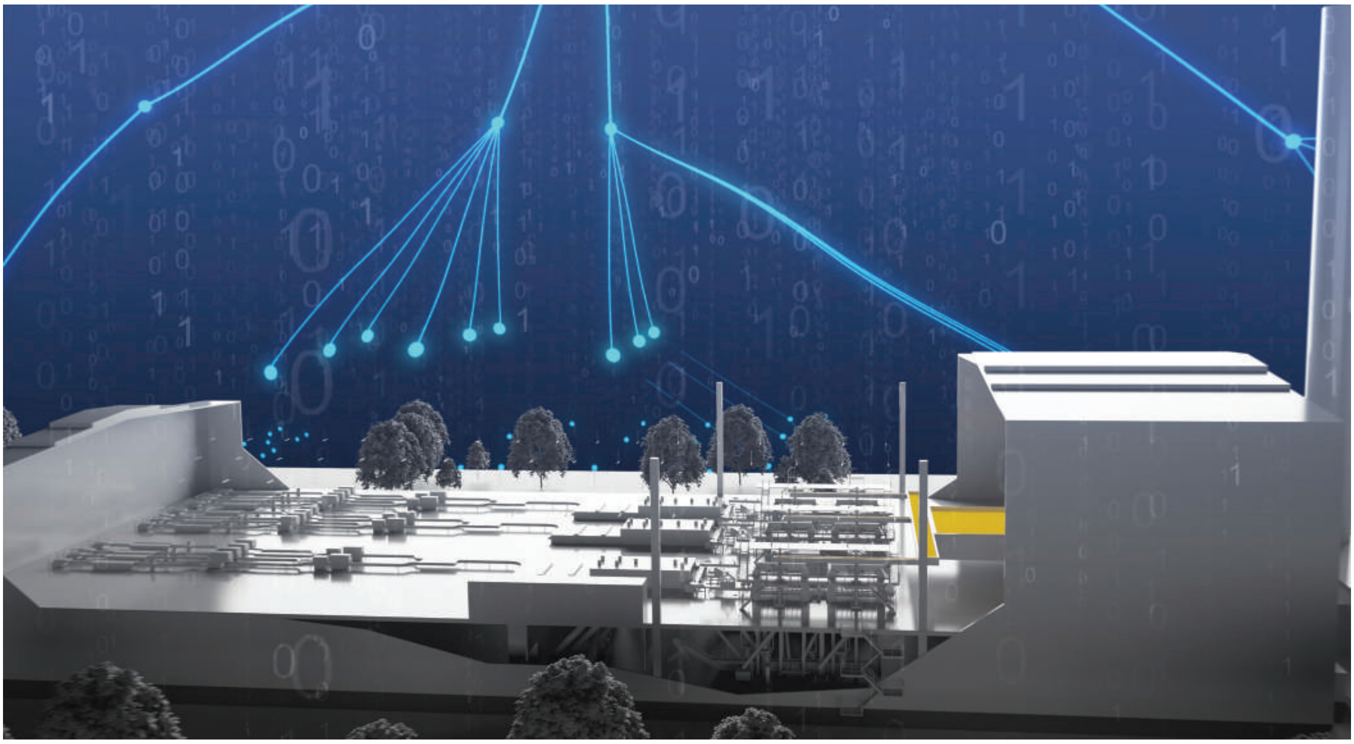

Fig. 3: Smart Plant

energy, you also save money. This is a strong incentive. The biggest cost factor in glass production is energy.

HEYE MACHINES ARE IN USE WORLDWIDE. REMOTE ACCESS AND REMOTE MAINTENANCE ARE BECOMING MORE AND MORE IMPORTANT. WHAT DO YOU NEED TO TAKE INTO ACCOUNT?

For remote access via the Internet, it is essential to consider security. Cyber criminals are lurking everywhere, and so companies are sealing themselves off more and more. This means that service providers cannot get into the company networks to connect to the machine and provide support from there without considerable effort. Solutions must be found in consultation with the IT departments of the customers.

HOW DO YOU ASSESS THE POTENTIAL OF ARTIFICIAL INTELLIGENCE FOR THE GLASS INDUSTRY?

AI is currently high on the agenda. I am now in the third wave: The first was in the 1980s, the second in the 1990s and the third is rolling now. You can certainly do a lot with artificial intelligence. But, you have to keep the boundaries in mind: Artificial intelligence is determined on the basis of learned information from the past. In order to learn a corresponding neural network, a large number of good and bad example objects are needed – we talk about 500 to 5,000 information. Gaining and learning these examples is a huge effort. And when new objects appear, the neural network cannot begin with them. There are AI applications, the decision is already working very well. In the glass industry, on the other hand, this only works for simple applications, such as reading mould numbers in the seven-segment code. Glass defects, on the other hand, become more difficult because they always look different. If new information is added that the trained system does not know, AI will not get any further. There are basically no two exactly the same checks. Perhaps a combination of imaging processes and neural networks can help, but that is still a dream for the future.

ABOUT HEYE INTERNATIONAL:

Based at Obernkirchen, Germany, Heye International GmbH is one of the international glass container industry's foremost suppliers of production technology, high performance equipment and production knowhow. Its mechanical engineering has set industry standards for more than five decades. Extensive industry expertise, combined with the positive attitude and enthusiasm of Heye International employees is mirrored by the company motto 'We are Glass People'. Its three sub-brands HiPERFORM, HiSHIELD and HiTRUST form the Heye Smart Plant portfolio, addressing the glass industry's hot end, cold end and service requirements respectively.

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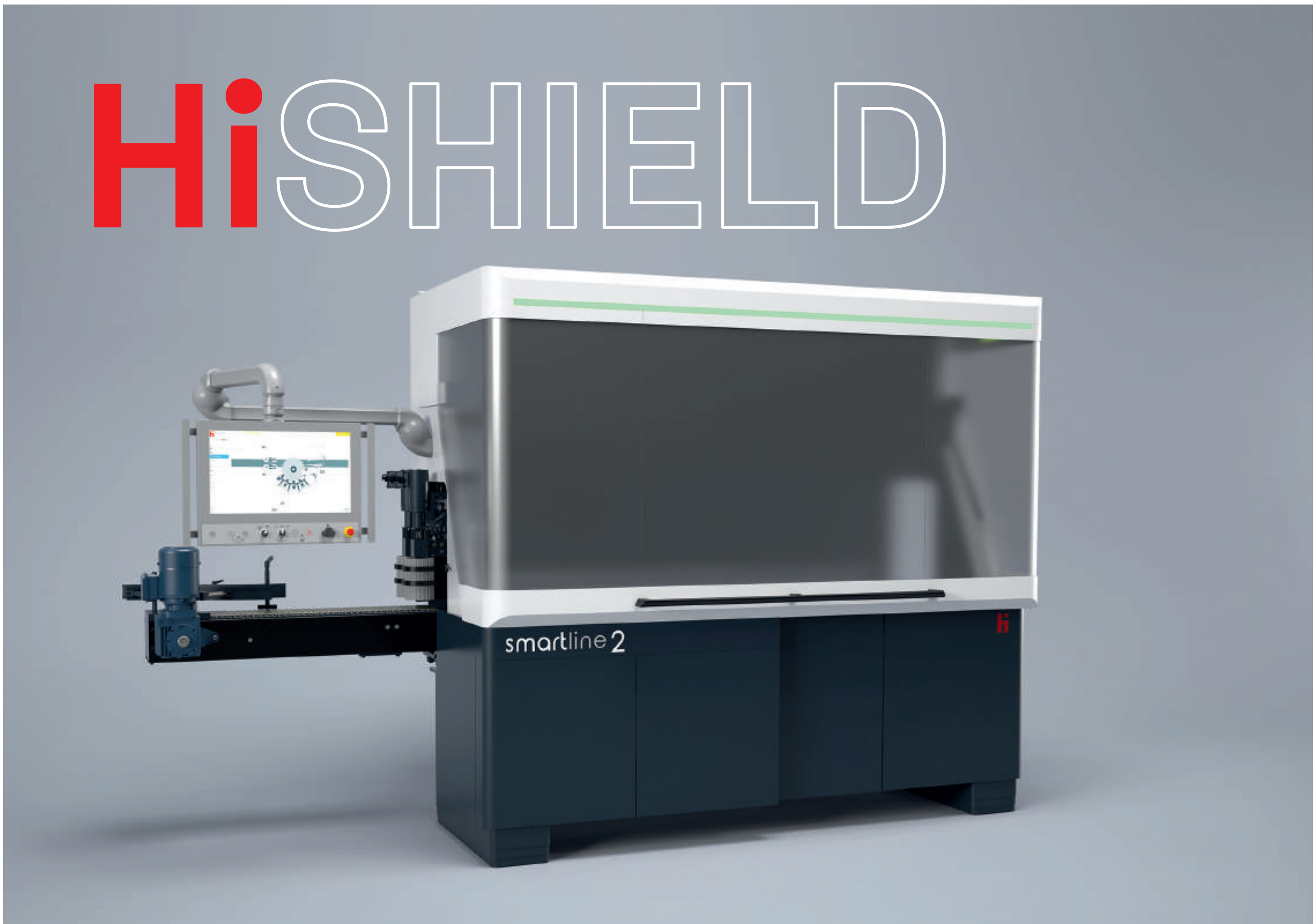

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