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SPECIAL ISSUE ARTICLE

International Journal of Applied Glass Science: Special Issue Editorial

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The Centre for ***Functional and Surface-functionalized glass*** (FUNGLASS, www.funglass.eu) is a glass research institute founded in 2017 as the result of joint efforts of five partners from four European countries: the Alexander Dubček University of Trenčín, Slovakia; Friedrich-Alexander University Erlangen-Nuremberg, Germany (FAU); the Spanish National Research Council, Madrid, Spain (CSIC); the University of Padova, Italy (UNIPD); and Friedrich Schiller University Jena, Germany (FSU); with massive financial support (15 million €) from the EU program Horizon 2020 under the scheme H2020-WIDESPREAD-01-2016-2017-TeamingPhase2, and the complementary support from the government of the Slovak Republic from the European Regional Development Fund in the frame of the Operational Program Research and Innovation (10 million €).

From the very beginning, the efforts of all five partners were focused on the promotion and support of a small glass research center of national significance (VILA), which had existed in Trenčín, Slovakia, since 1990, to achieve scientific excellence and international recognition in the selected areas of research. These areas reflected the field of expertise of all partners, and leading scientists from the three "old" EU countries—Germany, Italy, and Spain—became mentors and teachers of the team in Trenčín, transferring their know-how, but also friendship to their Slovak colleagues. In the three years from its official establishment, the Centre has grown significantly, becoming a truly international institution currently employing more than 70 researchers, PhD students and administrative and auxiliary staff, from 14 countries and all continents, except Australia and Antarctica.

The Centre consists of six intensively collaborating research departments sharing transversal research topics.

Department of Biomaterials, headed by Dr. Martin Michálek, currently with six researchers and three PhD students, focuses on the development and characterization of various bioactive materials, especially bioactive glasses, bioceramics, biopolymers, and their composites, their treatment and functionalization. The main aim is to overcome the current limitations of bioactive glasses and biomaterials, and to achieve new functionalities, with a specific focus on therapeutic factors such as targeted drug release, and tissue engineering applications. The momentum to its research activities gives a strong cooperation with the Institute of Biomaterials of the Friedrich Alexander University Erlangen-Nuremberg led by prof. Aldo R. Boccaccini.

Department of Coatings, headed by Dr. Amirhossein Pakseresht employs four researchers and three PhD students, and focuses its activities on the research, development, and characterization of coatings with special attention paid to sol–gel-based hybrid coatings for corrosion protection of

light metal alloys, sol–gel coatings for multifunctional applications on glass and metals, and antibacterial coatings on glasses. The department´s advanced partner and mentor is prof. Alicia Durán from the Institute of Ceramic and Glass, Spanish National Research Council.

Department of Functional Materials, led by Dr. José Velázquez-García, employs currently seven researchers, and supervises four Ph.D. students. The research activities of the department are focused on glass-based functional materials, especially luminescent glasses and glass ceramics applicable as inorganic phosphors, as well as transparent ceramic and glass-ceramic materials with luminescent properties for HB-LED and energy-saving lighting. Super-efficient optically active materials (e.g., paramagnetic glasses, super-spin glasses, and anisotropic glasses with high optical nonlinearity) are also in the focus of the department. The activities of the department are supported through intensive and efficient collaboration with the Laboratory of Glass Science of Otto Schott Institute of Materials Research, Friedrich Schiller University Jena, and mentoring provided by prof. Lothar Wondraczek.

Department of Glass Processing, currently the smallest, is led by Dr. Jozef Kraxner, and employs four researchers and one PhD student. The research interests are aimed at the development of new materials from waste glass, and recycling of waste from glass production. Such waste is converted into glass-ceramic foams, glasses, and glass-ceramics microspheres (solid, hollow, or porous) prepared by flame synthesis. Fabrication of waste-derived glass-ceramic composite materials by additive manufacturing techniques is also investigated. The key partner is Prof. Enrico Bernardo from the Università degli Studi di Padova (UNIPD), whose research activities focus on the conversion of industrial waste into a glass or raw materials for various engineering products (sintered glass-ceramic and glass products, composites, and foams with glass or glass-ceramic matrix, or innovative clay bricks).

Joint Glass Centre (VILA) is headed by the FunGlass director, prof. Dušan Galusek, and employs 10 researchers and two PhD students. The position of VILA within FunGlass is specific, being a joint laboratory of the TnUAD and the Institute of Inorganic Chemistry of the Slovak Academy of Sciences, one of the leading materials science institutions in the Slovak republic. As such, it also served as a nucleus for the foundation of the FunGlass Centre. Its research activities focus on fundamental relations between composition, structure, and physical properties of inorganic non-metallic materials, covering viscosity, electric properties, and relaxation phenomena in industrially relevant glasses. The development of new types of aluminate glasses and transparent ceramics with specific optical (luminescent) properties is another important area of research in the department, along with activities related to ion exchange-based modification of properties of glass and glass-ceramics.

Central laboratories are led by Dr. Dagmar Galusková, and employ six researchers, five technicians, and one PhD student. Within FunGlass the Central laboratories manage large research infrastructure, including electron microscopy, thermal analysis, X-ray diffraction, chemical analysis, and selected spectral methods. The Central laboratories provide expertise in these techniques, and support for horizontal research activities of other departments. Simultaneously, they foster their own research related to chemical analysis and archaeometry of historical glasses, corrosion of glass and ceramics (including biomaterials) with a specific focus on the early-stage dissolution kinetics of glasses in aqueous media, and development of corrosion-resistant layers for corrosion protection of metals.

A broad variety of our research topics, close collaboration with our partners, and among the FunGlass departments, are documented by the contributions in this special issue. The optically active materials cover a broad range of topics from fluorescent Dy^{3+}-doped borophosphate glasses with divalent modifiers, and optically non-linear Tm^{3+}/Tm^{3+}-Yb^{3+}-doped $NaLuF_4$ oxyfluoride glass-ceramics, through sol–gel-derived Nd^{3+}-doped LaF_3-SiO_2 oxyfluoride coatings, glass-ceramic Ce^{3+}-doped phosphors prepared by sintering of aluminate glass microspheres, to Er^{3+}/Yb^{3+} co-doped oxyfluoro tellurite glasses for temperature sensing applications. Our activities in the biomaterials field document the papers on the development and preparation of polycaprolactone fibers doped with bioactive glass mesoporous nanoparticles for tissue regeneration. Antimicrobial properties of conventional soda-lime silicate glass surfaces modified by multi-step ion exchange are also documented. Our research in coatings focuses mainly on corrosion protection, and is documented by the reports on the development of protective coatings on Mg-based alloys through anodization and deposition of sol–gel-derived layers, or with the use of graphene-based hybrid coatings. The effect of rare-earth and alkali doping on phase transitions in sol–gel-derived alumina coatings has been also studied. Successful preparation of two-dimensional thin-film mullite structures on glass substrates prepared by inkjet printing is also reported. Various ways of valuation and recycling of glass waste are documented by the reports on the use of flame synthesis for the preparation of borosilicate glass microspheres from cullet, and glass microspheres of åkermanite composition. Other ways of glass waste utilization are outlined in the papers related to new glass-based binders from engineered mixtures of inorganic waste, and alkali-free processing of advanced open-celled sinter-crystallized glass-ceramics. The Centre activities demonstrating the cross-cutting fields of research, or its interest in fundamental studies of glass structure and processes, are documented by the studies of the densification and crystallization of glass-ceramics evaluated with the use of master sintering/crystallization curve concept, investigations of the structure of historical glasses by Raman

spectroscopy, and development of a thermodynamical model for phosphate glasses.

Along with research activities, another important goal of the Centre is the education of a new generation of glass scientists and ceramists, with the ultimate aim to become a reference institution for glass education in the EU. At present, this is accomplished both by our postdoctoral fellowship program, and the doctoral program in the field of inorganic technologies and materials. In both, we collaborate closely with our advanced partners. Our postdoctoral fellows, after an open and thorough selection procedure, sign 2 years contracts: Out of the 2 years, they spend 1-year intensive training at one of our partner institutions, learning new experimental techniques, broadening their horizons, learning to accommodate to a highly competitive and international environment, and establishing the network of contacts. After returning to Slovakia, they utilize the newly gained expertise for their research projects. The best performing fellows are offered an extension of their contracts and further career prospects, including the possibility for time-unlimited contracts in the future. We are pleased to acknowledge, that the great majority of our fellows accepted the offered contract extensions, which they see as an excellent opportunity for further advancement of their career. So far, 34 research fellows from 11 countries went through the FunGlass postdoctoral research program or are currently under training.

A similar scheme is applied to our PhD program. After a highly competitive selection procedure (6 students selected from 60 candidates in the academic year 2019/2020, 9 selected from 99 candidates in the academic year 2020/2021), the students go through rigorous 4-year training, with the best candidates selected for the double-degree scheme with advanced partners. Such students spend at least one year of their study at an advanced partner institution under the supervision of the most respected scientists in the field. The Centre has already signed the first two co-tutelle agreements with FAU in November 2020, and a framework agreement on the double-degree doctoral study with UNIPD. Similar agreements with the FSU and CSIC are in preparation. The defense of the first two double-degree doctorates is anticipated in August 2021. For all registered PhD students, the Centre provides scholarships for the entire duration of their study to cover their living expenses in Slovakia, with additional supplements provided to the double-degree candidates to cover their living expenses in the partner country.

In its efforts, the Centre is aided by two important bodies: The Industrial Board, comprising representatives of the Slovak and European glass industry, and the International Advisory Board consisting of six leading world scientists, who help to focus our research efforts and to identify "hot" topics in glass science and technology. The former also helps the Centre in the identification of the topics of interest for the glass industry. Apart from routine service measurements of physical and chemical properties of various types of industrially relevant glasses, the FunGlass activities include systematic collaboration with industrial partners aimed at the optimized and energy-efficient glass melting and fining, energy savings by reduction of heat losses and waste heat recovery, low-emission glass melting, corrosion of refractories, and recycling of "unrecyclable" glass and waste from glass production.

We would like to express our deepest gratitude to the EU program Horizon 2020, and the Slovak government for helping us to build a success story of collaboration among R&D Centers, universities, and industry. We are proud and honored by the opportunity to present the results of this collaboration in the International Journal of Applied Glass Science.

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