Editorial: nucleation and crystallization of glasses and glass-ceramics

Health & Medicine

The Editorial on the Research Topic

Nucleation and Crystallization of Glasses and Glass-Ceramics

Glass-ceramic technology, which is based on materials built from glasses *via* controlled nucleation and crystal growth, is promising to provide us with materials of high strength, high toughness, unique electrical/electronic or magnetic properties, exceptional optical or unusual thermal or chemical properties. Glass-ceramic technology has been used also to develop materials, which exhibit exceptional properties of hot and cold processing such as moldability and machinability, and it aims for better combining flexibility of these material and process characteristics in the future. The greater diversity of microstructure-property arrangements and processing routes over glasses and ceramics are responsible that glass-ceramics are the preferred choice of materials in many technical, consumer, optical, medical/dental, electrical/electronic, and architectural fields. This includes increasing uses of glass-ceramic materials for environment and energy applications in the last decades.

The positive development of glass-ceramic technology has become true in particular due to the pioneering spirit, resourcefulness, and courage of researchers of the first generation. Extraordinary and, therefore, to be distinguished is the work of the glass-ceramic inventor S. Donald Stookey (Beall) to whom this Research Topic is dedicated. He had realized, as early as at the mid of the last century, that glass-ceramic properties are mainly influenced by the controlling of the mechanisms of nucleation and crystal growth to achieve desired microstructures in the volume of these materials.

The last decades saw development of the downstream thermal treatment of formed glass parts (called “ ceramming”) for a large variety of chemical systems, while nowadays, sintering of glass powders is available as a powerful route for glass-ceramic processing at lower fabrication temperatures and for complex shapes using powder compacts or slurry deposits on various substrates prepared by dipping, brushing, or spraying techniques or the emerging printing technologies (Höland and Beall, 2012 ; Müller and Reinsch, 2012). For both fabrication routes, crystal growth at or close to internal and external interfaces induced by heterogeneous nucleation is the key process transforming glass into glass-ceramic. Nucleation agents have been shown to trigger these processes in the volume of transparent glass-ceramics. Their coloration effects are subject of current developments (Nakane and Kawamoto). For sintered glass-ceramics, surface activation treatments by milling glass powders promote heterogeneous nucleation but these processes can cause gas release during the subsequent sintering step. To overcome limitations of sintered glass-ceramics for energy applications, such as SOFC sealants, measures to reduce the bubble formation are now being studied intensively (Agea-Blanco et al.). Further, activation of both heterogeneous surface and heterogeneous volume nucleation processes of sintered glass-ceramics is currently gaining importance for dental applications (Rampf et al.). To study the interplay of heterogeneous and homogeneous nucleation in glass-ceramic materials from a more fundamental point of view, current academic research is focusing on the underlying stochastic nature of the crystal nucleation process (Krüger and Deubener).

Ceramming is the core process in the case of consumer products and appliances. In order to achieve near-net shape fabrication, *in situ* analysis of changes in the thermomechnical behavior concurrent with the microstructure evolution is increasingly gaining attention (Fu et al.). For further performance improvements, additional, post-ceramming heat treatments with respect to ion-exchange and mechanical strength development have found renewed interest. The recent status of ion-exchanged glass-ceramics is reviewed in this topical issue (Beall et al.). The precipitation of optically active crystals can also be widely controlled by glass-ceramic technology. Efficient down-conversion processes in transparent glass-ceramics are one of the emerging fields where rare earth ions can be used to promote solar cell efficiency (Gorni et al.). Furthermore, laser-induced crystallization is shown to be attractive alternative to usual ceramming, which can provide novel functionalities to glass-ceramic materials by spatially selected patterning of non-linear optic crystals in glasses. Intensive R&D is now providing us with new insides on the mechanisms that control crystal growth directions (Komatsu and Honma). Glass-ceramic is also very attractive for hosting apatite crystals. Current directions in the development of apatite glass-ceramics for orthopedics, dentistry, optoelectronics, and nuclear waste management are re-evaluated in this Research Topic (Duminis et al.).

Author Contributions

This contribution is an editorial. As such, the topic editors equally contributed to this introduction.

Conflict of Interest Statement

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

Acknowledgments

We would like to thank all the authors, reviewers, editors, publishers, and members of the Technical Committee 07 (Crystallization and Glass-ceramics) of the International Commission on Glass (ICG) who have supported this Research Topic.

Funding

The Topic Editors acknowledge the Coordinating Technical Committee (CTC) of the International Commission on Glass (ICG) for supporting the “ 11th International Symposium on Crystallization in Glasses and Liquids” October 11–14, 2015 in Nagaoka, Japan.

References

Höland, W., and Beall, G. H. (2012). *Glass-Ceramic Technology* . Hoboken, NJ: Wiley.

Google Scholar

Müller, R., and Reinsch, S. (2012). “ Viscous phase silicate processing,” in *Processing Approaches for Ceramics and Composites* , eds N. Bansal and A. R. Boccaccini (Hoboken, NJ: John Wiley & Sons), 75–144.

Google Scholar