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Optimizing fused silica for commercial fusion energy applications

Eduard Klett [(1)], Wolfgang Schlichting [(2)], Bodo Kühn [(1)], Dr. Mark Altwein [(1)], Dr. Frank Nürnberg [(1)]

[(1)] Heraeus Quarzglas GmbH & Co. KG, Germany

[(2)] Heraeus Quartz North America LLC, USA

Laser based nuclear fusion represents a promising approach to achieving sustainable and clean energy. However, the development of efficient laser fusion facilities faces significant challenges particularly in the production of optical components that can withstand the intense conditions of (short-pulse and ultra-short-pulse) laser peak power and at the same time are economically scalable and cost-efficient in high volume manufacturing. Heraeus Covantics is part of PriFUSIO, an initiative funded by BMBF (German Federal Ministry of Education and Research). We aim to address these challenges by developing cost-effective fused silica material optimized for these challenging conditions.

The objective is to consolidate and optimize the fabrication process of large-format plates to enhance the efficiency and cost-effectiveness of mass production. Furthermore, the suitability of different fused silica grades will be investigated regarding their resistance properties to short and ultra-short laser pulses to identify the optimal material composition. This comprehensive approach identifies the optimal material composition, while ensuring significant reductions in manufacturing time and costs, leading to a substantial increase in production capacity.

We are presenting our initial results from material screening across various wavelengths, pulse widths, and materials. Key findings include material selection, laser-induced damage threshold (LIDT), optical homogeneity, presence of bubbles and inclusions, and striae, with the tested plate size being up to 1500x500x60 mm. The significance of this research work lies in its potential to meet the commercial and technical requirements of laser fusion power plants. The findings could also benefit other new market segments for fused silica beyond laser fusion applications.

Preliminary results show that the success of this project ensure a reliable supply of high-quality, cost-effective fused silica material for the rollout of fusion power plants in Germany and worldwide, addressing both commercial and technical challenges.