Domino-like crystallization of glass

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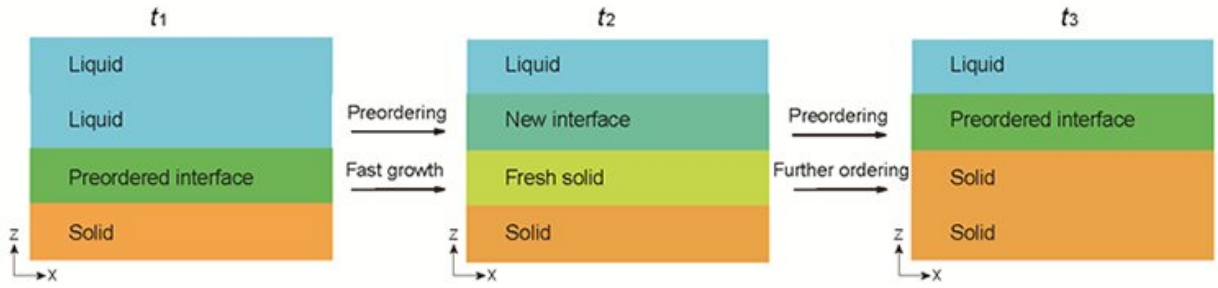

Credit: University of Tokyo

Materials in a glassy state are everywhere in our lives and have contributed to humanity for many years. Today, they play a critical role in various technologies, including optical fibers. Although we believe that glass is highly stable, it sometimes crystallizes, resulting in loss of transparency and isotropy, essential characteristics of glass, which has been a significant problem in industrial applications. The reason why crystallization occurs in a solid-state with almost no molecular movement has been a great mystery. Its understanding may help to prevent or optimize crystal growth at deep supercooling.

In a study recently published in *Nature Materials*, researchers from the Institute of Industrial Science, The University of Tokyo, Fudan University, Peking University, and collaborating institutions have conducted experimental and computational studies on fast crystal growth

under deep supercooling. Their work provides critical insight into the mechanism of fast crystal growth at ultra-low temperatures, contributing to many technological applications by enhancing glass stability or producing high-quality crystals.

"Crystal growth in glasses is a complex, decades-old problem. How precursor structures overcome disorder in the liquid phase to arrange into crystals remains controversial," says Peng Tan, co-senior author.

A key to fast crystal growth revealed by simulations and experiments is that the solid-liquid interfaces in the supercooled liquids are thick and rough. The large contact area between ordered islands and the surrounding disordered liquid helps break up the disorder and facilitates rapid crystal growth.

"Another key result is that the disordered state is inherently unstable mechanically, leading to a domino-like chain reaction of crystal growth," explains Hajime Tanaka, co-senior author. "This is facilitated by the ability of the newly formed imperfectly ordered regions of the crystal to re-order and in so doing prevent accumulation of disorder."

How can researchers use this knowledge? One can promote crystal growth by enhancing a supercooled liquid's ability to develop precursor structures and rearrange itself from sub-optimized ordering. Tanaka, Tan, Xu, and coworkers are optimistic that researchers will use these insights to figure out which materials exhibit the necessary properties for enhanced glass stability or high-quality crystal formation. With further development, there are clear applications to ultrastable glasses and nearly perfect crystals.

More information: Qiong Gao et al, Fast crystal growth at ultra-low temperatures, *Nature Materials* (2021). DOI: 10.1038/s41563-021-00993-6

Provided by University of Tokyo