High pressure is key for better optical fibers

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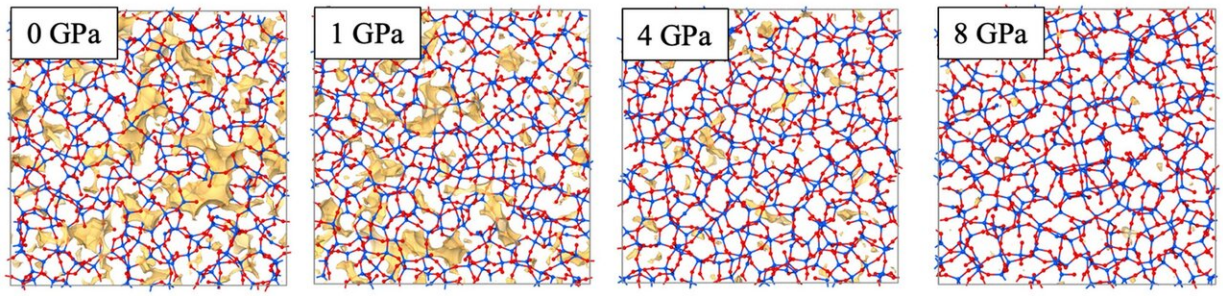

The voids in silica glass (yellow), which are responsible for scattering of light and degradation of signals, become much smaller when the glass is quenched at higher pressures (Yongjian Yang, et al., npj Computational Materials, September 17, 2020). Credit: Yongjian Yang, et al., npj Computational Materials, September 17, 2020

Optical fiber data transmission can be significantly improved by producing the fibers, made of silica glass, under high pressure, researchers from Japan and the US report in the journal *npj Computational Materials*.

Using computer simulations, researchers at Hokkaido University, The Pennsylvania State University and their industry collaborators theoretically show that signal loss from silica glass fibers can be reduced by more than 50 percent, which could dramatically extend the distance data can be transmitted without the need for amplification.

"Improvements in silica glass, the most important material for optical communication, have stalled in recent years due to lack of understanding of the material on the atomic level," says Associate Professor Madoka Ono of Hokkaido University's Research Institute of Electronic Science (RIES). "Our findings can now help guide future physical experiments and production processes, though it will be technically challenging."

Optical fibers have revolutionized high-bandwidth, long-distance communication all over the world. The cables carrying all that information are mainly made of fine threads of silica glass, slightly thicker than a human hair. The material is strong, flexible and very good at transmitting information, in the form of light, at low cost. But the data signal peters out before reaching its final destination due to light being scattered. Amplifiers and other tools are used to contain and relay the information before it scatters, ensuring it is delivered successfully. Scientists are seeking to reduce light scatter, called Rayleigh scattering, to help accelerate data transmission and move closer towards quantum communication.

Ono and her collaborators used multiple computational methods to predict what happens to the atomic structure of silica glass under high temperature and high pressure. They found large voids between silica atoms form when the glass is heated up and then cooled down, which is called quenching, under low pressure. But when this process occurs under 4 gigapascals (GPa), most of the large voids disappear and the glass takes on a much more uniform lattice structure.

Specifically, the models show that the glass goes under a physical transformation, and smaller rings of atoms are eliminated or "pruned" allowing larger rings to join more closely together. This helps to reduce the number of large voids and the average size of voids, which cause light scattering, and decrease signal loss by more than 50 percent.

The researchers suspect even greater improvements can be achieved using a slower cooling rate at higher pressure. The process could also be explored for other types of inorganic glass with similar structures. However, actually making glass fibers under such high pressures at an industrial scale is very difficult.

"Now that we know the ideal pressure, we hope this research will help spur the development of high-pressure manufacturing devices that can produce this ultra-transparent silica glass," Ono says.

More information: Yongjian Yang et al. Topological pruning enables ultra-low Rayleigh scattering in pressure-quenched silica glass, *npj Computational Materials* (2020). DOI: 10.1038/s41524-020-00408-1

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