Ceramics Composites & Optical Materials Center (CCOMC)

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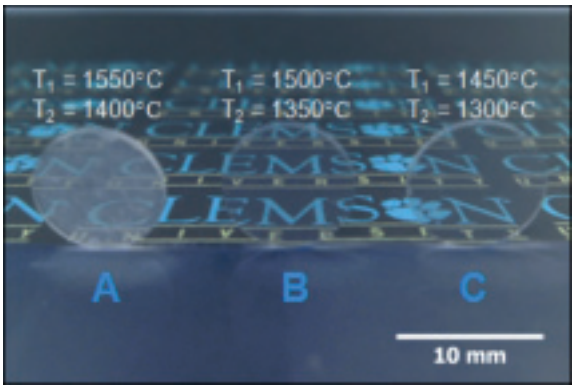
Ceramics – Normally Opaque – Made Highly Transparent

Researchers at the Ceramics, Composites, and Optical Materials Center have refined ceramics that have glass-like transparency for light to pass through. For millennia ceramics have been commonly opaque and brittle.



Highly transparent ceramic (C), of value to next-generation laser and sensing systems, optimized from samples of lesser transparency (A and B) based on control over the granular microstructure with temperature (process temperatures noted).

This work, conduct at Clemson University and initially funded by the Department of Defense, has developed ceramics that are highly transparent and are considerably tougher than conventional analogs. Such materials are of value to a wide variety of applications including high power compact lasers, transparent armor, and radiological sensing technologies.

Conventional ceramics are opaque because light is scattered from residual voids in the granular microstructure. Clemson researchers developed processes that fully remove voids and limit structural evolution so that the new ceramics possess features that are smaller than the size of light. More specifically, a two-step temperature process was established that yields ceramics with granular structures that are only 300 nm in average diameter. For comparison, one's hair is about 300 times larger.

The attainment of full density while maintaining sub-light granular dimensions permits transparency equivalent to glass. The reduction in granular size scales also yields significant enhancements in the mechanical hardness and toughness of the ceramics as required for armor and high power lasers applications.

Economic Impact: As with many other important modern technologies, transparent ceramics were invented in the United States. However, for over a decade now, Japan has been the world leader in the production of transparent ceramics largely due to a decline in US funding and science competitiveness. This work, originally supported to help regain domestic know-how in fabricating transparent ceramics, has additionally facilitated the establishment of a domestic education and industrial supply chain critical to the future use of these materials in various defense, security, and sensing applications. While there are a few commercial examples of trans-

parent ceramics, they remain a fairly young technology. Accordingly, the exact economic impact is unclear but ceramics certainly have the potential to displace crystals and glasses in numerous high technology fields as development continues. To that end, lasers, ultra-hard materials, and sensors represent multi-billion-dollar domestic industries that will only become more important as defense and security threats expand.

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