

Ultra-tough and impact resistant glasses with bioinspired architectures

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Glass is a widely used engineering material because of its optical properties, hardness, durability, thermal and chemical stability. However, at ambient temperature glass is brittle with poor impact resistance. Despite improvements in strength (tempering) and impact behavior (lamination), glass components remain by far the weakest structural elements in vehicles, buildings and electronic devices. In this work we have developed a series of transparent, glass-based materials that overcome the inherent brittleness of glass, with designs and architectures inspired from mineralized tissues such as bone, teeth or mollusc shells: (i) Hard and stiff building blocks, (ii) thin, soft and highly deformable interface materials [1], (iii) precise, near-periodic 3D architectures to induce collective micro-mechanisms over large volumes [2]. We have applied these guidelines to a variety of glass-based materials with various architectures combined with transparent thermoplastic elastomers: Ultra-tough glass with jigsaw-like sutures 200 tougher (in energy terms) than regular glass by way of interlocking, geometric hardening and frictional contact [3]; cross-ply laminated glasses that can stretch by up to 80% by the collective rotation and shearing of individual plies [4]; nacre-like glass panels (Figure 1) with superior impact resistance and graceful, quasi-ductile failures from large scale nacre-like sliding of glass tablets on one another [5]. The fabrication methods we used (lamination, laser engraving) can be applied to the large-scale production of high-performance glasses for a wide range of applications including protective structures, windows, photovoltaic systems, building materials and electronic devices.

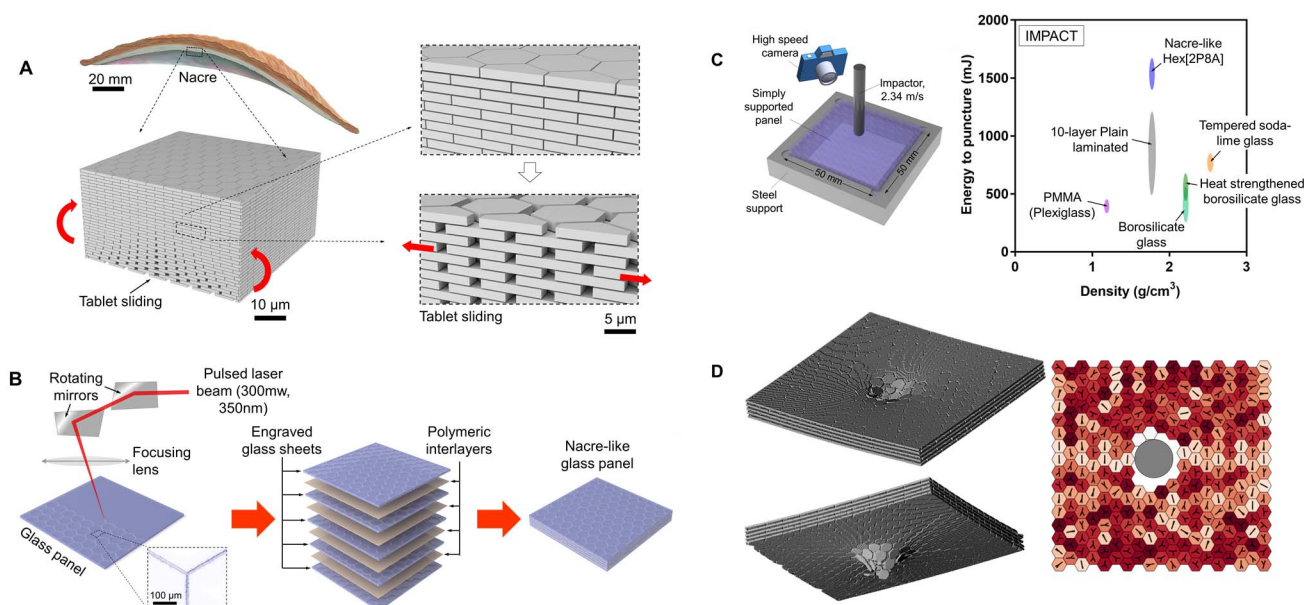


Figure 1. (A) Natural nacre can deform, stop cracks and absorb impact energy by the sliding of the micro-tablets on one another and over large volumes; (B) Fabrication protocol for nacre-like glass panels; (C) Impact tests on large nacre-like panels and other transparent materials: Nacre-like panels provide superior impact resistance with “ductile” behavior and graceful failure; (D) Micro-CT of post-mortem nacre sample and quantitative analysis showing nacre-like tablet sliding over large volumes.

References

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