

### **Abstract**

Nanostructured silica frustules produced by photosynthetic alga can be assembled into low-density ( $\rho \leq 1\text{g/cm}^3$ ) hierarchical ceramic materials which exhibit favorable thermal behavior as high-temperature insulators. Our materials exhibit thermal conductivities lower than common inorganic insulators, such as bulk magnesium oxide, polydimethylsiloxane elastomer, and polymethyl methacrylate, with melting temperatures between 700 and 1100°C, depending on the frustule makeup and the mass ratio of frustules to binder. These properties make silica biosynthesis a viable avenue for the future manufacturing of environmentally sustainable high-performance thermal materials, particularly in space-exploration contexts where the biological nature of biogenic silica would allow small-scale synthesis of thermal materials in space or on the Moon or Mars.