# Double-Negative-Index Ceramic Aerogels For Thermal Superinsulation

Tech ID: 30234 / UC Case 2019-495-0

## SUMMARY

UCLA researchers in the Departments of Chemistry and Biochemistry and Materials Science and Engineering have developed a novel ceramic aerogel material that has robust mechanical and thermal stability under extreme conditions.

## BACKGROUND

Thermal insulation used in industries like aerospace and thermal power fields requires resistance to rapid temperature changes and long-term high-temperature exposure. Ceramic aerogels are appealing for thermal insulation due to their low density, low thermal conductivity, and exceptional fire/corrosion resistance. However, ceramic aerogels can be brittle and suffer structural collapse upon exposure to prolonged high-temperature or large thermal gradients. Prior strategies to improve structural stability have employed flexible amorphous, one-dimensional fibrous materials, but these ceramic aerogels still break down under extreme conditions. There is significant motivation to create alternative constructs with improved ceramic strength to maintain thermal and mechanical stability.

## INNOVATION

UCLA researchers have developed a ceramic aerogel material that has increased mechanical and thermal stability under large thermal gradients or extended high-temperature exposure. The material is protected from strength degradation and structural collapse in extreme environments. Its structural stability relies on a unique fibrous/film hybrid meta-structure that exhibits a negative Poisson's ratio and negative thermal expansion coefficient, in contrast to ceramic aerogels with one-dimensional fibrous structures. The novel ceramic aerogel displays ultralow density (~0.1 mg/cm3), superelasticity (up to 95%), and thermal superinsulation (~2.4 mW/m K in vacuum and ~20 mW/m K in air). The material is able to withstand sharp thermal shocks (~275 ℃/s) and long-term temperature exposures (900 ℃ in air and 1,400 ℃ in vacuum), which is significantly improved compared to other ceramic aerogels.

## APPLICATIONS

- Thermal superinsulation under extreme conditions, such as in aerospace and thermal power fields
- Mechanical stability under rapid temperature changes and long-term high temperature exposure

## ADVANTAGES

- Ultra-low density (~0.1 mg/cm3)and super lightweight compared to other ceramic aerogels
- Thermal superinsulation beyond typical aerogels
- Near-zero strength loss under rapid thermal shocks and extended high temperature exposure
- Enhanced torsion flexibility and superelasticity of compression (up to 95%) that exhibits highest deformability

## STATE OF DEVELOPMENT

This invention has been designed and evaluated for its mechanical properties, as well its ability to withstand extreme conditions.

## PATENT STATUS

| Country | Type | Number | Dated | Case |
|---|---|---|---|---|
| United States Of America | Issued Patent | 12,054,436 | 08/06/2024 | 2019-495 |

## RELATED MATERIALS

## CONTACT

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## INVENTORS

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## OTHER INFORMATION

### KEYWORDS

ceramics, aerogel, ceramic aerogel, negative-index, thermal insulation, superinsulation, nanosheets, nanomaterials, aerospace, graphene

### CATEGORIZED AS

- **Materials & Chemicals**
  - Ceramics
  - Nanomaterials
  - Negative Index
- **Nanotechnology**
  - Materials

### RELATED CASES

2019-495-0

▶ Xu, X. et al. Double-negative-index ceramic aerogels for thermal superinsulation. Science, 363(6428), 723-727 (2019). doi: 10.1126/science.aav7304.

## ADDITIONAL TECHNOLOGIES BY THESE INVENTORS

- ▶ Approaching Schottky-Mott Limit in Van Der Waals Metal Semiconductor Contacts
- ▶ Ultrafine Nanowires As Highly Efficient Electrocatalysts
- ▶ Chemical Vapor Deposition Growth of the Large Single Crystalline Domains of Monolayer and Bilayer
- ▶ Single-Atom Tailoring of Platinum Nanocatalysts for High-Performance Multifunctional Electrocatalysis
- ▶ Palladium Alloy Hydride Nano Materials
- ▶ High Performance Thin Films from Solution Processible Two-Dimensional Nanoplates



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