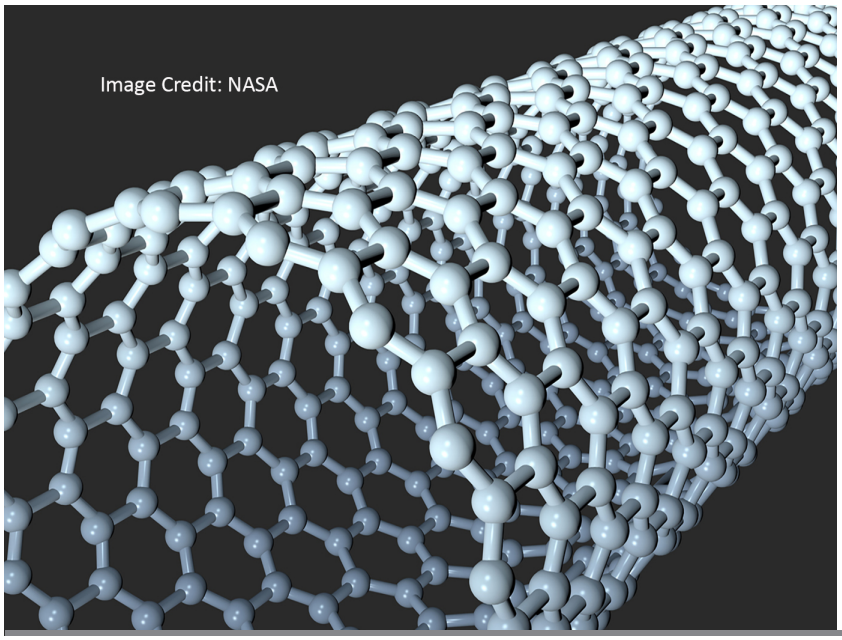


National Aeronautics and Space Administration

TECHNOLOGY SOLUTION

Materials and Coatings

Lightweight Hypersonic Thermal Protection Material

Flame and hypersonic flow resistant boron nitride nanotube (BNNT) mat

State of the art high temperature shielding materials are not flexible. This technology forms the structurally robust, thermally stable BNNT into a low weight, flexible mat.

BNNT advancements are highly sought after because they are as strong as carbon nanotubes, but they have a much higher resistance to heat, high voltage, and neutron radiation.

The flexible BNNT mat can provide temperature protection up to 1300°C with density of 200-400 kg/m^{3}.

BENEFITS

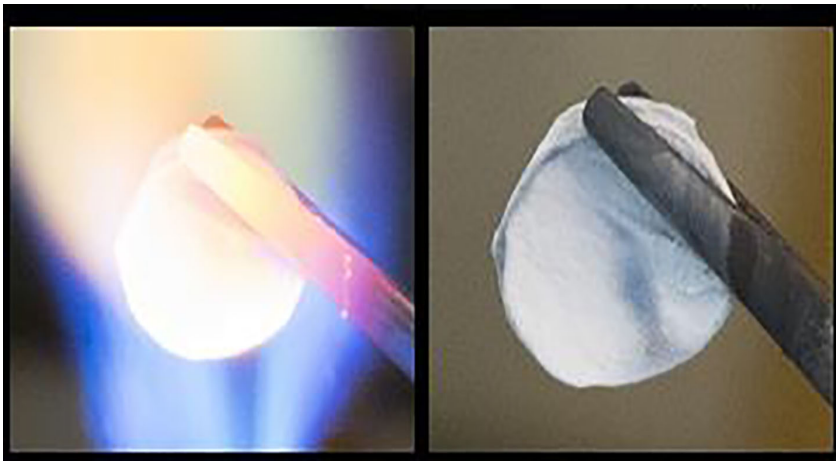
- Withstands 1300 C with thermal flux rate of 50 W/cm1300 square
- Flexible mat
- Process forms a protective boron oxide passivation layer
- Electrically non-conductive
- White base color that can be dyed
- Can be used to make woven and non-woven flexible fabrics
- Resists high temperatures and direct flame
- Self-extinguishing
- High thermal emissivity

THE TECHNOLOGY

Originally developed as a flexible thermal protection system (FTPS), this BNNT mat was designed to shield a 40-ton craft from the high aerothermal flux of atmospheric entry, descent, and landing. The novel lightweight flexible BNNT mat is an excellent flame retardant material and has shown excellent thermal stability and shielding capabilities under a hypersonic thermal flux test in air.

The novel BNNT mat or fabric creates an in-situ passivation layer under high thermal flux which minimizes penetration of the atmosphere (air or gas) as well as heat and radiation through the thickness. BNNT effectively diffuses heat throughout the mat or fabric laterally and radially to minimize localized excessive heat. In addition, the lightweight flexible BNNT mat can efficiently alleviate the heat via radiation because of its high thermal emissivity.

This invention offers a lightweight, simple, single layer BNNT FTPS with better thermal protection and flame retardation performance in extreme environments while providing structural robustness. The novel BNNT materials can also serve as flame retardants and flame retardant additives in composite systems that are also potentially more colorable compared to carbon nanotube additives.



Sample of BNNT mat under torch, shown unscathed after test - Image Credit: NASA

APPLICATIONS

The technology has several potential applications:

- High temperature electrical insulation
- Fire resistant structural cabling
- Thermal insulation in aircraft & jet engines
- Piezoelectric applications
- Reinforced high temperature composite materials
- Lightweight radiation shielding
- Aerospace thermal shielding
- Building insulation
- Personal protective clothing
- Appliance, automotive, and industrial high temperature insulation applications

PUBLICATIONS

Patent No: 10,934,028

Boron Nitride Nanotube (BNNT) and BNNT Composites: Overview, Cheol Park, Sang-Hyon Chu and Catherine Fay. NSTRF Student Meeting at JPL, Pasadena, CA, August 4-6, 2019. https://ntrs.nasa.gov/api/citations/20200003735/downloads/20200003735.pdf

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