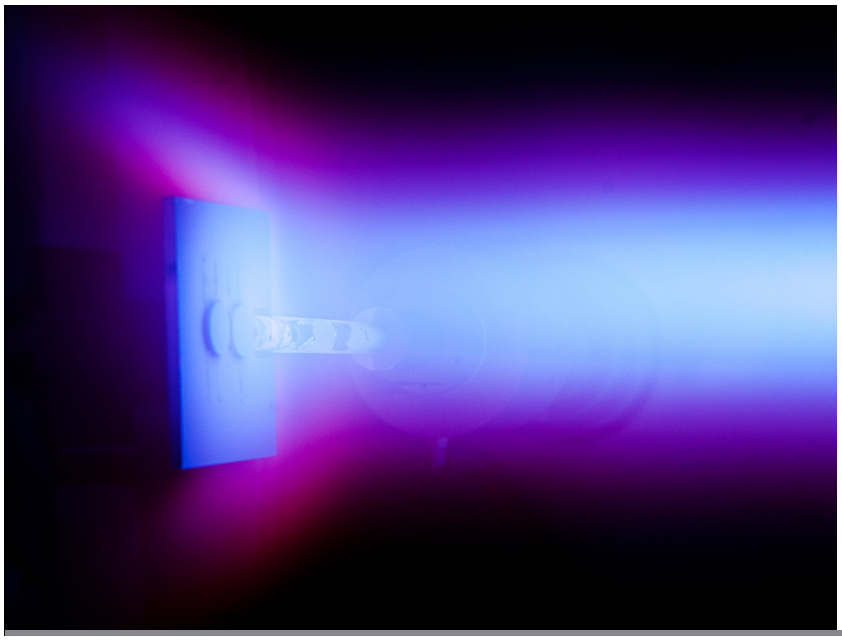


National Aeronautics and Space Administration

TECHNOLOGY SOLUTION

Materials and Coatings

Conductive High-Toughness Oxides

Metastable phases provide unique coatings with durable, conductive, and insulating properties

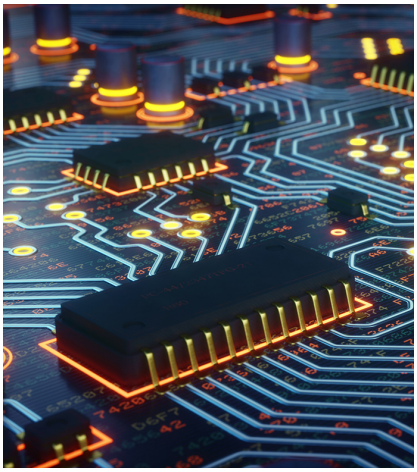
Innovators at NASA's Glenn Research Center have developed a novel method for making oxide coatings that have excellent mechanical strength and electronic conductivity at room temperature. Using the Plasma Spray-Physical Vapor Deposition (PS-PVD) processing methodology, Glenn researchers have been able to produce a coating containing a metastable phase that no other method can achieve. Upon exposing the material to moderate temperatures (greater than 300°C) in the presence of oxygen, the metastable phase is further oxidized, and the material becomes insulating while retaining its high toughness and microstructure. With this innovation, a coating can be created from any metal oxide, including rare earth oxides, zirconium oxide, hafnium oxide, titanium oxide, or any combination of two or more oxides. Glenn's innovation has great potential for industries that require increasingly tough ceramic coatings, such as electronics, chemical and petroleum refineries, the aerospace industry, and automotive and aeronautics manufacturing.

BENEFITS

- Durable: Has very good toughness and erosion resistance
- Efficient: Combines low thermal conductivity with electrical conductivity
- Flexible: Can change coating composition and microstructure by changing the processing parameters and can coat complex shapes with limited manipulation
- Simple: Can be deposited in a single step
- Uniform and Dense: Suitable for porous and non-porous metals and ceramics, turbine engine components, and SiC/SiC semiconductors substrates/devices

THE TECHNOLOGY

Oxide coatings have been used in thermal and environmental barrier layers for coatings for hot section turbine applications, among other uses. With the PS-PVD method, Glenn researchers observed the formation of a minority phase of a metastable oxide (zirconium oxide) that is usually found only in a vapor state. They found that the high temperatures and fast deposition process of the PS-PVD system incorporated nonequilibrium phases in the coating and retained them at room temperature as well as at high temperature in the absence of oxygen. The material is vaporized and condensed on the surface via a rapid quenching, essentially "trapping" this phase in the deposited coating. The coating microstructure and composition can also be manipulated by changing the processing parameters, allowing the thickness of the coating to be tailored to a given application. Since this metastable phase is conductive, this coating can be used as (for example) an extremely sensitive (thermal or temperature) sensor. It also has very good durability and erosion resistance, making it useful as a protective and conductive coating for electronics and microelectronics. This is an early-stage technology requiring additional development, and Glenn welcomes co-development opportunities.



Glenn's oxide coatings are extremely durable and erosion-resistant, making them ideal for use in electronics, microelectronics, and sensors

These tough ceramics coatings are very effective for thermal and environmental barriers in refineries and similar industries

APPLICATIONS

The technology has several potential applications:

- Aerospace
- Automotive
- Chemical manufacturing
- Coatings (e.g., heat and environmental protection)
- Electronics (e.g., thermal cut-off, thermistors)
- Filters (e.g., gas separation membranes)
- Insulation
- Oil and gas
- Power (e.g., ionic conduction membranes)
- Semiconductors

PUBLICATIONS

Patent No: 11,047,034

Patent Pending

technology.nasa.gov

NASA's Technology Transfer Program pursues the widest possible applications of agency technology to benefit US citizens. Through partnerships and licensing agreements with industry, the program ensures that NASA's investments in pioneering research find secondary uses that benefit the economy, create jobs, and improve quality of life.

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