Skysong Innovations
Advancing the Arizona State University Knowledge Enterprise

1475 N. Scottsdale Road, Suite 200
Scottsdale, AZ 85287-3538
Phone: 480 884 1996 Fax: 480 884 1984

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Inventors

Jagannathan Rajagopalan

Rohit Sarkar

Contact

Shen Yan
shen.yan@skysonginnovations.com

Method for Producing Custom TiAl Nanocrystalline Alloys with Full 3D Microstructure Control

Nanocrystalline alloy coatings prevent oxidation and corrosion while improving a material's electrical or mechanical properties. While nanocrystals provide significant advantages in performance, they often become unstable if subjected to heat or stress and lose their benefit as they merge and the crystals grow larger. The grain boundaries between the crystals have a crucial effect on an alloy's properties, determining how much temperature and stress a crystal can endure before its boundaries merge. Current methods, such as severe plastic deformation or electrodeposition, produce inexact structures with randomly distributed crystals that can have grain boundaries greater than 100 nm and are not always nanocrystalline. Other methods, such as sputtering or mechanical attrition, can only produce small samples, acutely limiting their capability to engineer nanocrystalline materials with custom microstructures.

Researchers at ASU have developed a method for producing custom TiAl nanocrystalline alloys with full 3D microstructure control. Recrystallization is tailored by systematically seeding nanocrystallites into a custom amorphous matrix, which controls the density and distribution of grain nucleation sites. ASU researchers chose titanium aluminide (TiAl) because it provides exceptional resistance to high-temperature oxidation and chemical degradation, and is widely used to used in aerospace and automotive applications. However, this method is not limited to the aforementioned alloy, and can be extended to industrial scale processes for bulk production, including electrodeposition. This new ability to customize 3D microstructures allows for the production of stronger alloys with superior mechanical, thermal, and chemical properties, and significantly enhances a nanocrystalline coating's performance and lifetime.

Potential Applications

- Alloy Coatings
- Boiler Tubing
- Electroplating
- Jet Engines
- Steam Turbines
- Turbochargers

Benefits and Advantages

- Performance – Control over grain boundaries allows production of stronger alloys with superior properties and extended lifetimes.
- Retrofit – Can be extended to industrial scale processes for bulk production, including electrodeposition.

- Versatility – Can be utilized with any nanocrystalline alloy.

For more information about the inventor(s) and their research, please see

Dr. Jagannathan Rajagopalan's directory webpage