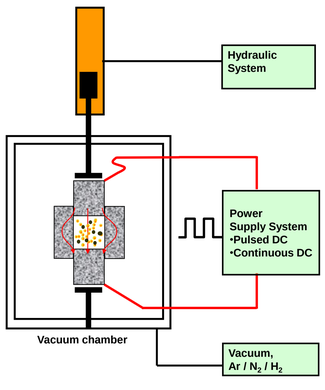
Processing of Metals, Ceramics, and Composites by Field Assisted Sintering Technology (FAST) for MHD Power

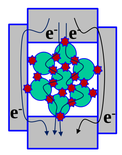
Professor Jogender Singh's Research Group

Phone: 814-863-9898, E-mail: jxs46@psu.edu

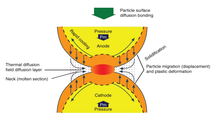
Field Assisted Sintering Technology

Field assisted sintering technology (FAST) is an emerging manufacturing technology, where heating rate as high as 1000°C/min are achieved by the simultaneous application of pressure, high temperature and high density pulsed current. In FAST, volumetric heating leads to dense compact with fewer defects at temperatures that are 200 to 250 ^{0}C lower than the temperatures used during conventional sintering. FAST is a promising solution in processing high temperature materials or composites with minimal grain growth.



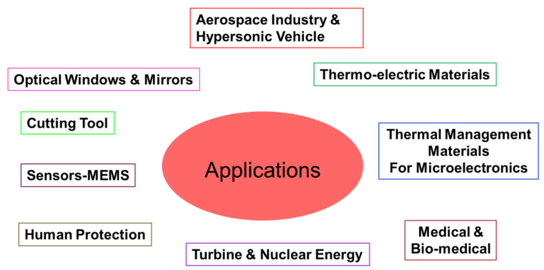


Electric current distributed to the powder and die to generate heat by Joule heating



Localized heating at the particles interface

Applications

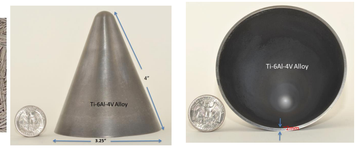


Research Activities
Light Weight Metals / Alloys

Ti-6Al-4V with Boron Addition Processed via Field Assisted Sintering

FAST Ti-6Al-4V with 1.6 wt. % B addition reduced the average grain size of FAST Ti-6Al-4V from 600 mm to 100 mm. The resulting material is 20% harder and 16% stronger than the commercially rolled Ti-6Al-4V.

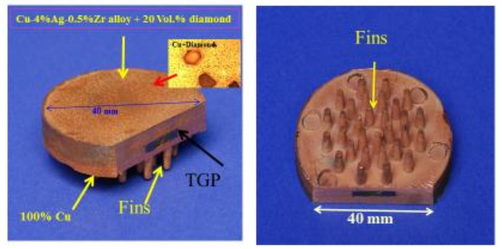
Optical Micrograph of Ti-6Al-4V Fabricated via Fast



Net-Shaped Fabrication of Ti-6Al-4V Components Fabricated vua FAST

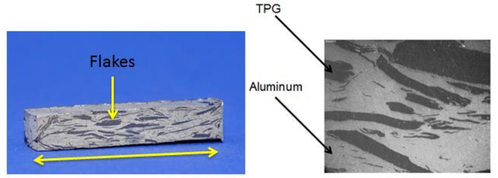
Hybrid Thermal Management Materials

Copper Alloy with Diamond Consolidated via FAST

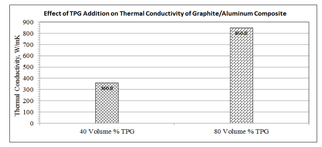


Tailored hybrid heat sink components with fins-fabricated in one step Technology ready to be transferred to industries

Thermal conductivity of Al-Thermally Grown Pyrolitic (TGP) Graphite Flakes Composite



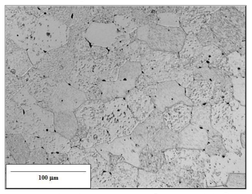
Microscopic and Macroscopic Images of Graphite / Aluminum Composite containing TPG

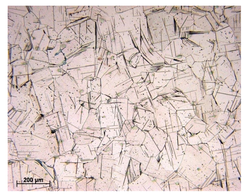


Effect of TPG Addition on the Thermal Conductivity of Graphite/Aluminum Composite

Refractory Metals

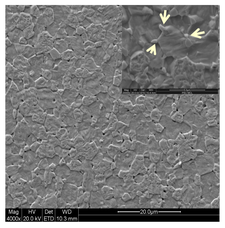
• Tungsten and tantalum were sintered to ~99% density without any additives.

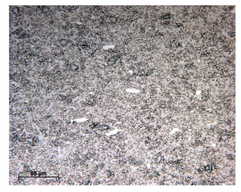




Tungsten (W): Sintered at 1900 ^{0}C, 85MPa, 30 min, Density =98.5%

Tantalum (Ta): Sintered at 1700 ^{0}C, 75MPa, 5 min, Density =99.0%

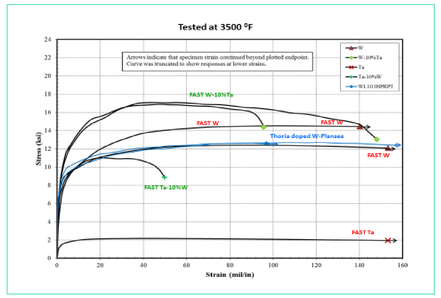


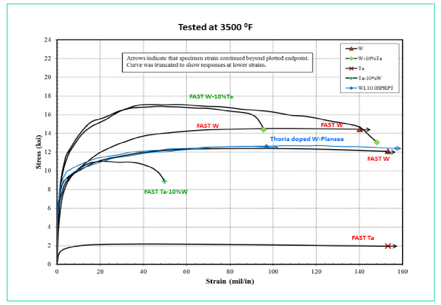


W-10%WC : Sintered at 1700 ^{0}C, 85MPa, 5 min, Density =98.7%

Ta-10%WC : Sintered at 1600 ^{0}C, 75MPa, 5 min, Density =98.8%

** WC additive reduced sintered grain size in both W and Ta down to ~10% of the samples without WC at the same sintered density.

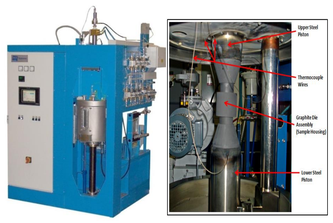


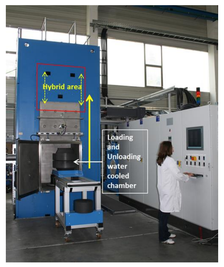


Summary

Variety of materials and composites have been produced successfully by FAST. Superior properties have been observed. This technology would expand the horizon of new materials development.

FAST Facilities at Penn State





:
- **Equipment capability load : 25 Ton**
- **Maximum Diameter: 80 mm**
- **Pulse current: 0 - 10KAmps**
- **Pulse time: 1 to 1000 ms**
- **Pause duration: 0 to 1000 ms**
- **Temperature: RT to 2400 ^{0}C**
- **Computerized Process control system**

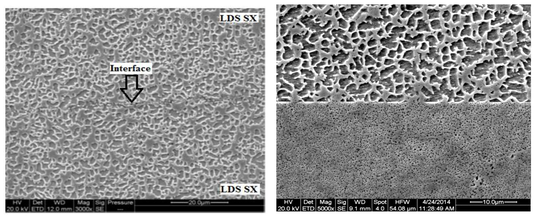
- **Equipment capability load : 250 Ton**
- **Maximum Diameter: 300 mm**
- **Pulse current: 0-10KAmps**
- **Pulse time: 1 to 1000 ms**
- **Pause duration: 0 to 1000 ms**
- **Temperature: RT to 2400 ^{0}C**
- **Computerized Process control system**

- **Equipment capability load : 400 Ton**
- **Maximum Diameter: 400 mm**
- **Pulse current: 0-10KAmps**
- **Pulse time: 1 to 1000 ms**
- **Pause duration: 0 to 1000 ms**
- **Temperature capability: RT to 2400 ^{0}C**
- **Computerized Process control system**

*** The units are supplied by FCT company, Germany*

Joining of Single Crystal Nickel-Based Superalloy for Gas Turbine Prupulsion

Joining of Low Density Single Crystal (LDS) and Poly Crystalline Low Solvus High Refractory (LSHR) Nickel Superalloy



SEM Image of LDS Joined to A) LDS and B) LSHR