

Poster Presentation Charts for
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High Thermal Conductivity NARloy-Z-Diamond Composite for Advanced Rocket Engines

Objectives:

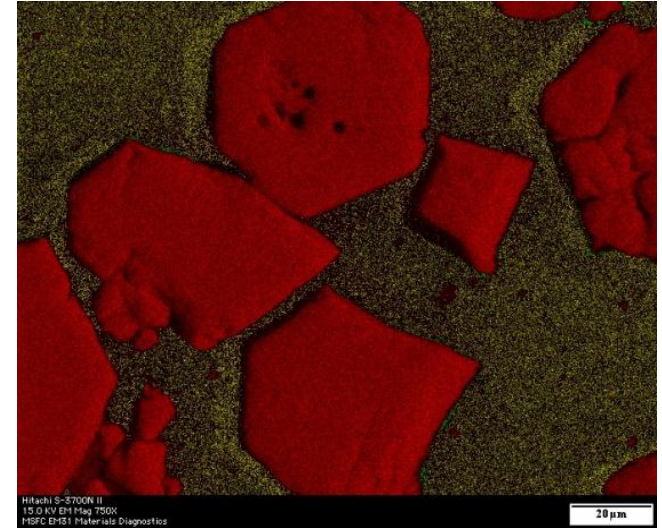
- Develop high thermal conductivity NARloy-Z-Diamond composite (NARloy-Z-D)) material for advanced rocket engines
- Develop near net shape fabrication technique for NARloy-Z-D combustion chamber liner

Technical Goals:

- Significant improvement in thermal conductivity over state of the art NARloy-Z alloy
 - up to 2X
- Significant improvement in the performance of combustion chamber liner made from NARloy-Z-D

Target Applications:

- Combustion chamber liner for advanced rocket engines
- Thermal management systems for nuclear propulsion system



NARloy-Z-40vol.% Diamond Composite Microstructure

Research Team:

NASA Principal Investigator:

Dr. Biliyar N. Bhat/Marshall Space Flight Center (MSFC/EM31)

NASA Co-Investigator:

Dr. Sandra Greene (MSFC/ER32)

External Co-Investigator:

**Dr. Jogender Singh/Pennsylvania State University (PSU) – Applied
Research Laboratory (ARL)**

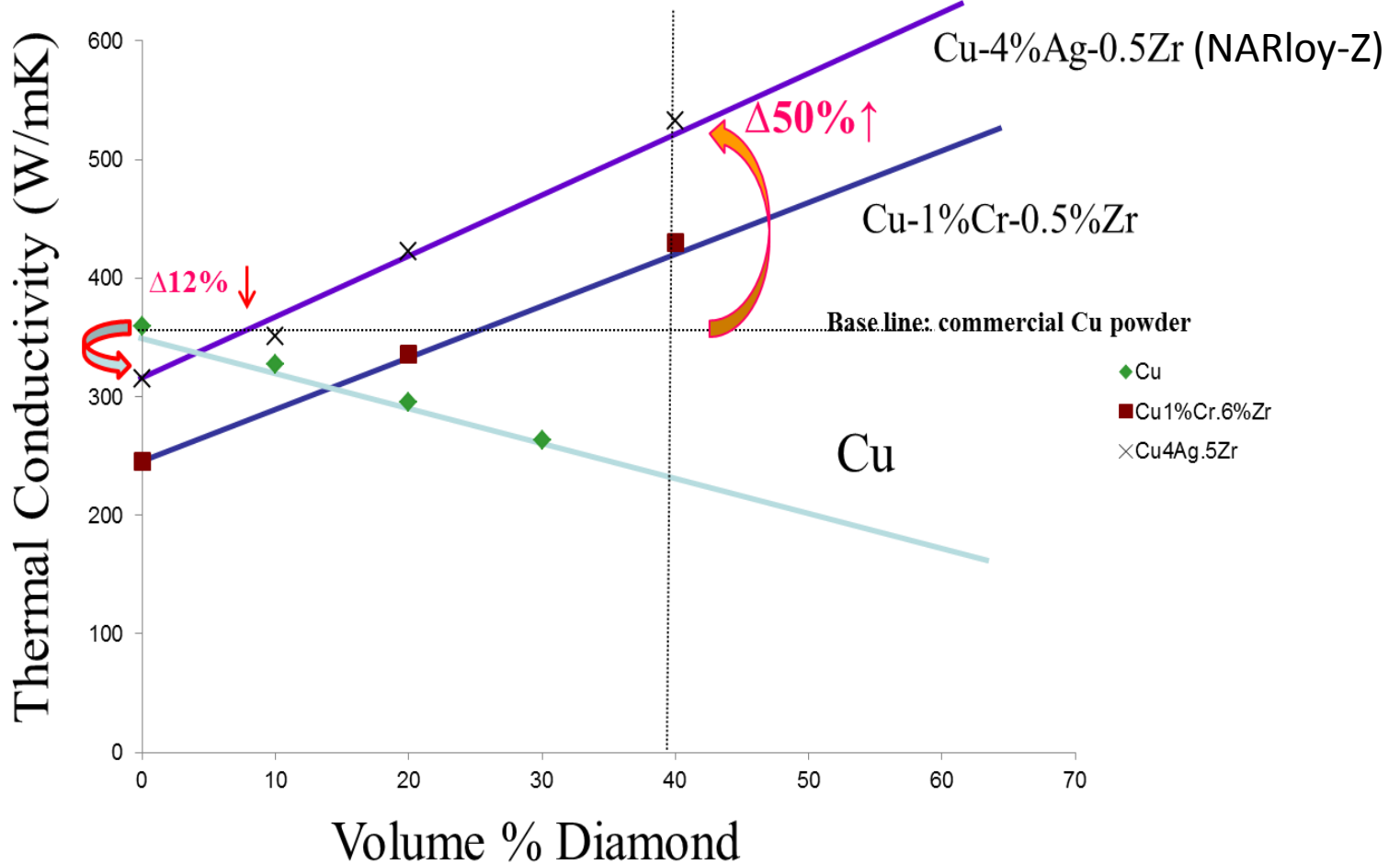
Consultant:

Dr. David Ellis (NASA-GRC)

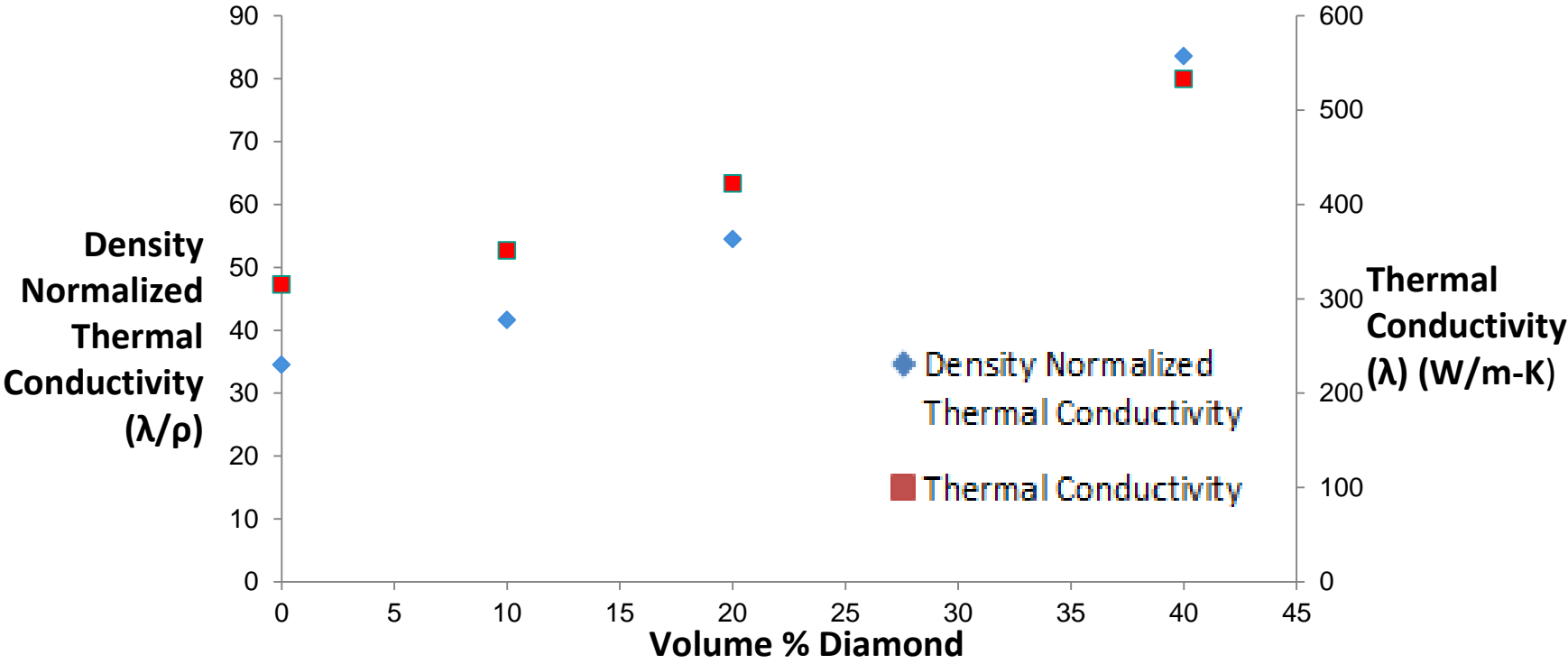
Technical Approach

- **Blend NARloy-Z powder with up to 40 volume% of diamond powder to produce NARloy-Z-D composite mixture**
- **Sinter at elevated temperature using Field Assisted Sintering Technology (FAST) at Pennsylvania State University (PSU)**
- **Characterize NARloy-Z-D composite**
 - **Microstructure analysis: SEM, TEM, XPS, EDS**
- **Develop design properties**
 - **Thermal conductivity measurements – RT to 1000°F**
 - **Tensile testing at room and elevated temperatures**
- **Net shape forming of combustion chamber liner using FAST**
- **Hot fire testing of combustion chamber liner**

Thermal conductivity of NARloy-Z-Diamond Composites

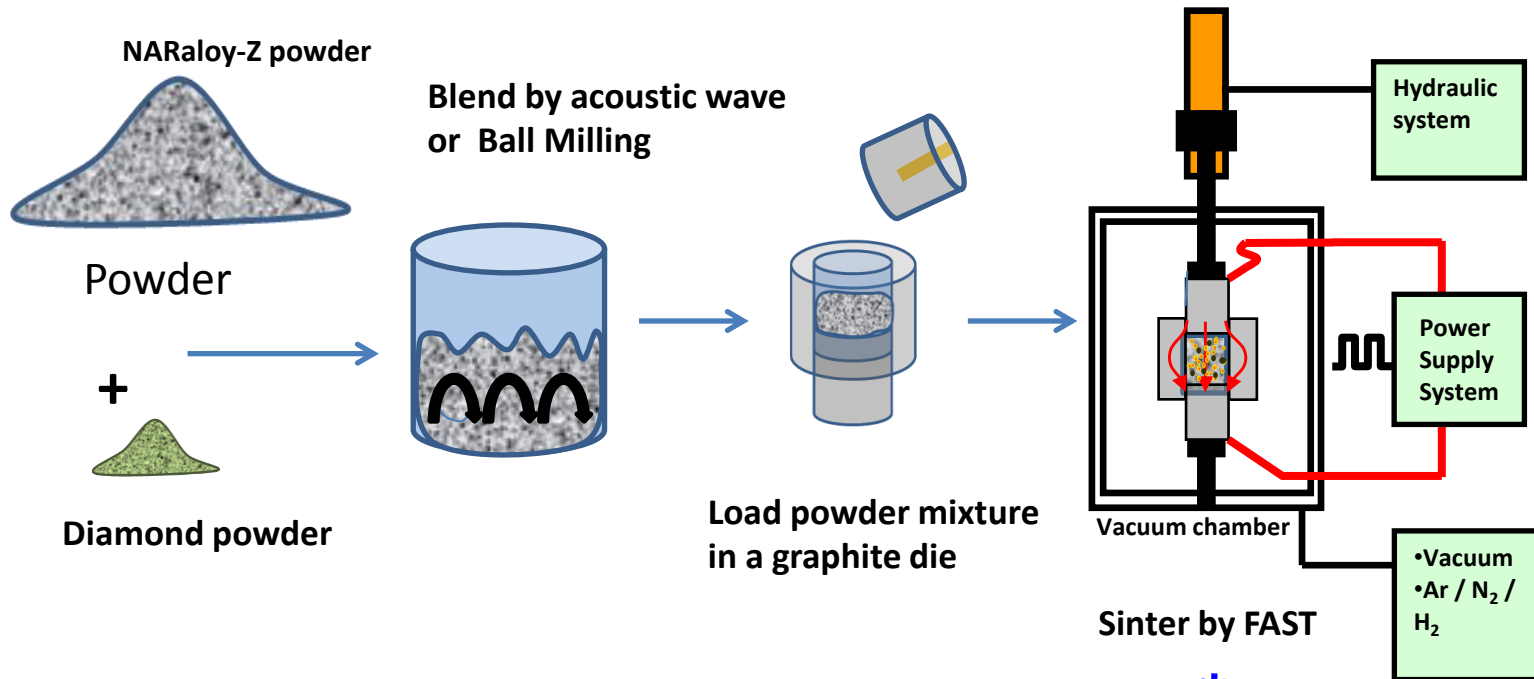


Density Normalized Thermal Conductivity of NARloy-Z-Diamond Composites



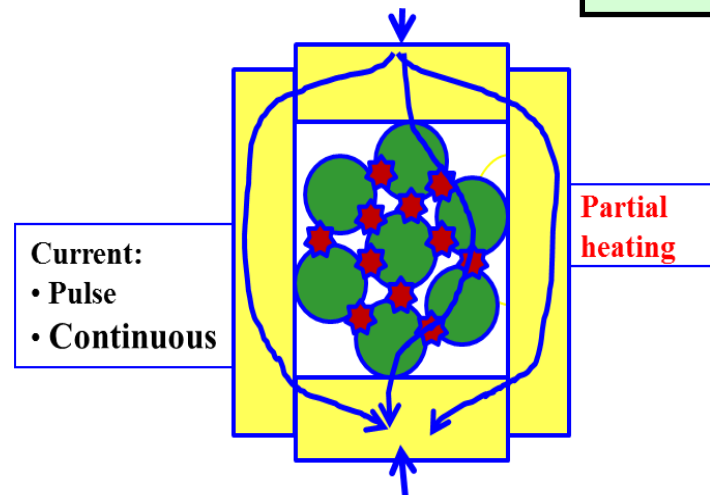
140% improvement in density normalized thermal conductivity at 40 Vol.% Diamond

Sequence of powder mixing and sintering by Field Assisted Sintering Technique (FAST)



Compaction and sintering process variables:

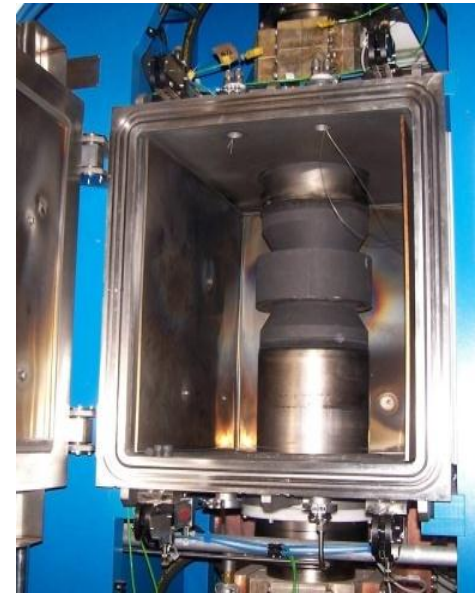
- Pressure
- Temperature
- Current density
- Time at temperature



Field Assisted Sintering System At Penn State - ARL



- 250 ton Prototype Large R&D system
- Maximum Diameter: 300 mm
- Pulse current: 0-10KAmps
- Pulse time: 1 to 1000 ms
- Pause duration: 0 to 1000 ms
- Temperature capability: RT to 2400 °C
- Computerized Process control system

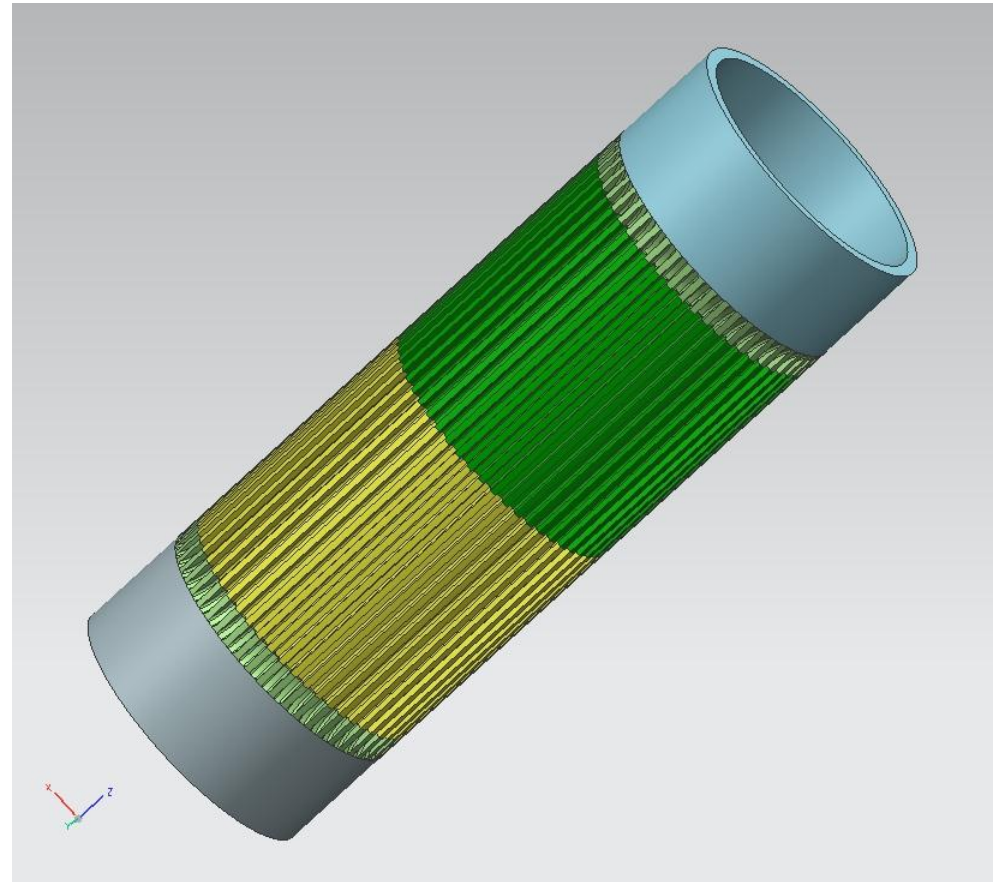
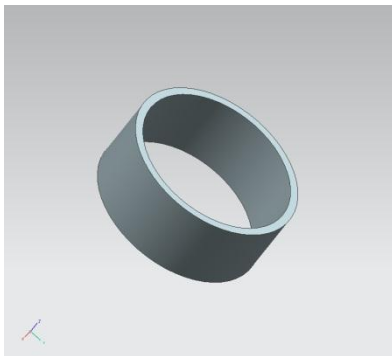
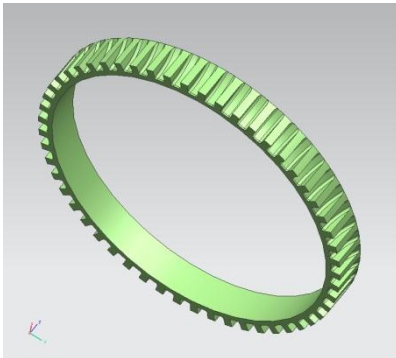
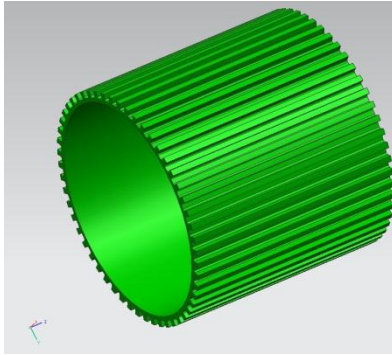


Inside view of furnace chamber



Sintering at high temperature

Net Shape Liner Fabrication by FAST



Parts are diffusion bonded to make the liner

Hot fire Testing of NARloy-Z-Diamond Liner



**Combustion chamber
liner and test assembly**



**Hot fire testing at MSFC
Test stand**

Test data will be analyzed to determine performance