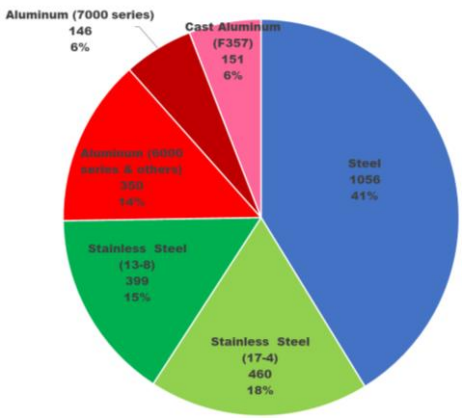
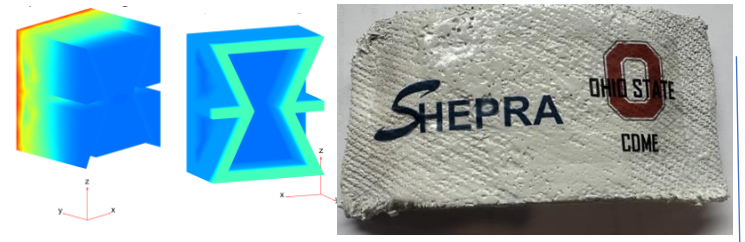
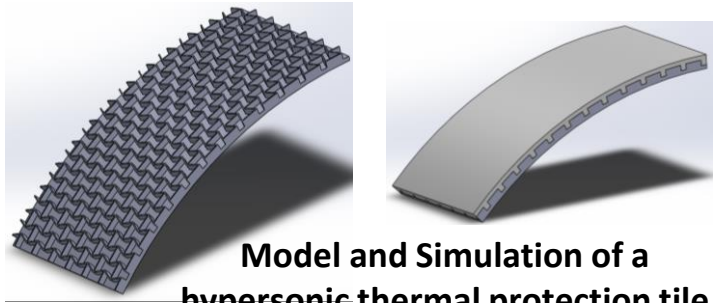
Rapid, Accelerated Certification and Evaluation of Advanced Materials for Additive Manufacturing (RACE A^2M^2)



Breakdown of Maintenance and Sustainment Needs





Model and Simulation of a hypersonic thermal protection tile

Objective: Development of extensive material property database to enable the use of Additive Manufacturing in multiple applications**.**

Benefits: Address DoD issues in maintaining and sustaining current systems while enabling the development of new systems with advanced capabilities.

Approach: Leverage $5.25 million of prior DoD investment in Carbon Nanotube Metal Matrix Composites. Focus mechanical and physical properties that enable high value applications.

Collaborators: SHEPRA, Ohio State CDME, Laser Fusion Solutions, Open Additive, Skyward, Powder Alloy Corporation

Deliverables:

1. Development of mechanical and physical properties databases that enable the use of wrought aluminum alloys for use in maintenance and sustainment of current systems and for use in light weight structures in new applications and systems. (i.e. Fatigue, Fracture, Use at Elevated Temperature, and Corrosion)
2. Development of mechanical and physical properties databases that enable the use of Nickel alloys for use in Hypersonic and Propulsion applications. (i.e. Creep, Rupture, Use at Elevated Temperatures, and Fatigue)

DoD Science & Technology Priority:
Advanced Materials & Manufacturing
Space Technologies
Hypersonics

JobsOhio Priority:
Advanced Manufacturing
Aviation & Aerospace
Defense & Federal

Budget Request

Item / Task	Non-Reoccurring	Reoccurring
AM processing parameter / Post Process Heat Treatment Certification	$1,000 K	--
Certification and Evaluation of Aluminum Alloys for Maintenance and Sustainment Applications	$2,500 K	--
Certification and Evaluation of Nickel Alloys for Hypersonic and Propulsion Applications	$2,500 K	--
Total	$6,000 K	--

FY'25 Congressional Budget Request: $6,000K
Program Element: ***Air Force Applied Research- Materials: 0602102F***

DREAM Overview

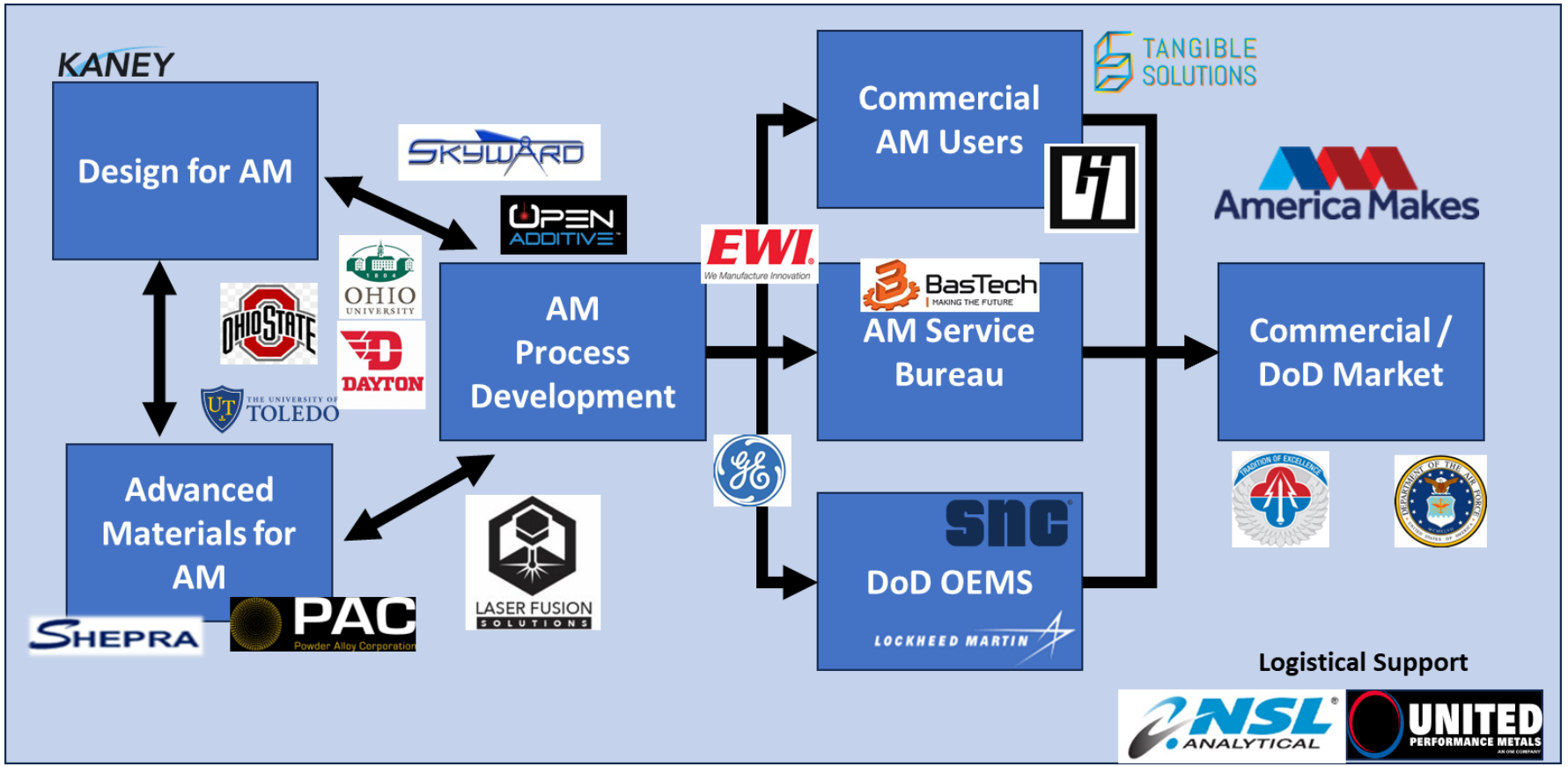
Objective: Spur economic growth by developing keep capabilities and technologies that support the utilization of Additive Manufacturing

Opportunity: The greater Dayton region and the state of Ohio have established a nascent ecosystem that supports the emerging technology of Additive Manufacturing.

- This ecosystem includes:
  - *Raw materials production and advanced material development,*
  - *Fabrication of additive manufacturing systems,*
  - *Sensor and software development for AM quality assurance*
  - *Contract Additive Manufacturing and logistical Support*
  - *Fabrication of Aerospace and Biomedical components and devices*

Approach: Execution of individual projects that collectively develop the workforce and enable new technologies that expand the Additive Manufacturing capabilities of the ecosystem and transition to DoD and Commercial OEMs and spur economic development.

DREAM Value Stream



DoD Science & Technology Priorities

Advanced Materials & Manufacturing
Artificial Intelligence & Autonomy
Space Technology
Hypersonics

Jobs Ohio Priorities

Advanced Manufacturing
Aviation & Aerospace
Military & Federal
Automotive

The DREAM value stream spans the entire innovation pipeline to turn concepts and capabilities into market realities

Additive Manufacturing Focus

Maintenance & Sustainment

Potential Parts for Additive Manufacturing

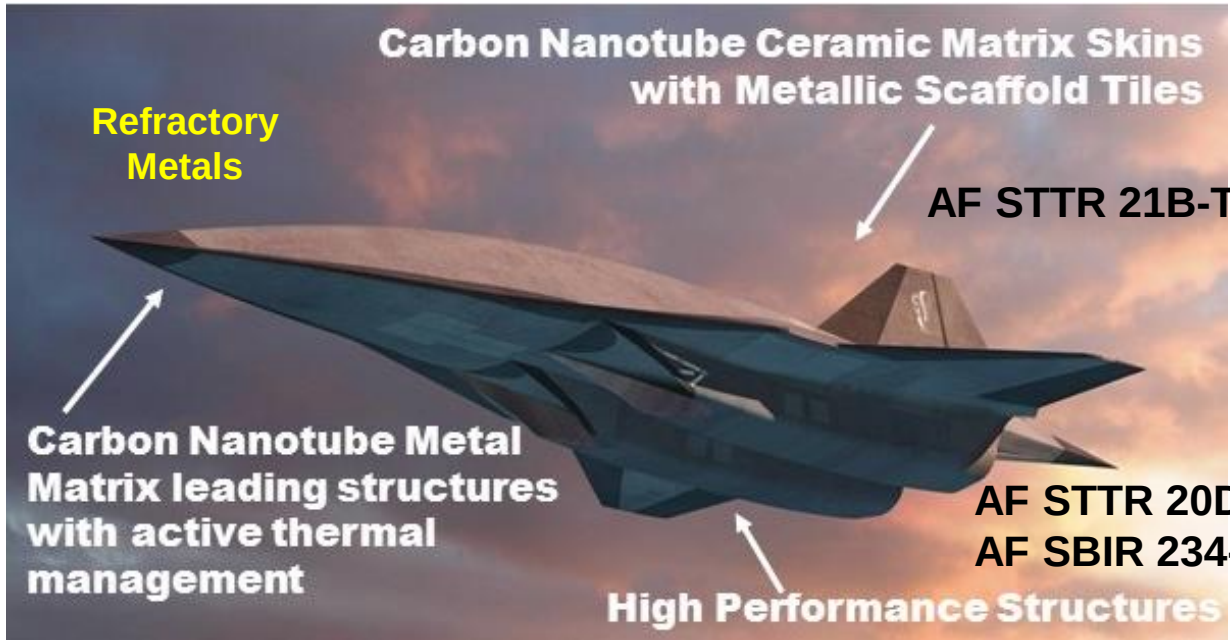
	Steel	Stainless Steel (17-4)	Stainless Steel (13-8)	Aluminum (6000 series & others)	Aluminum (7000 series)	Cast Aluminum (A356)
# parts	1207	900		572		
# part Families	68	40		75		
# AM Parts	1056	460	399	350	146	151
Proposed Replacement Materials	In 718 (NA 718) UDRI	IN 718 (NA 718) UDRI	IN 718 (NA 718) UDRI	Ti-6-4 UDRI		F357 UDRI
SHEPRA Material	IN 718 CNMMC	17-4 CNMMC	IN 718 CNMMC	Hybrid 6061 CNMMC	Hybrid 7075 CNMMC	N/a
	Haynes 230 CNMMC		Haynes 230 CNMMC			
SBIR / STTR Program	AFX 234 SBIR	Navy 16A-T007 STTR	AFX 234 SBIR	AF 20D STTR	AFX 234 SBIR	N/ a
	AF 20 D STTR		AF 20 D STTR			

Material Families	# Backordered Part Numbers	Total Backorders	# IPG-1 Part Numbers	# IPG-1 Backorders
Stainless Steel	72	38144	49	23501
Steel	52	24655	20	3292
Aluminum	9	16	5	14

Initial assessment of four (4) of eleven (11) AFLCMC / EBW IPTs
Additive Manufacturing is not suitable for >95% of the inventory

Data from June 2022

New Product Development



Structural Hypersonic Thermal Protection

SHEPRA's carbon nanotube metal matrix composites has application in Maintenance and Sustainment and New Systems Development

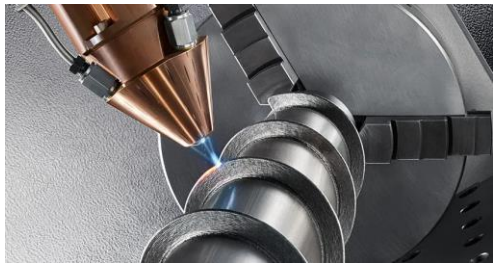
America Makes

SHEPRA Inc.

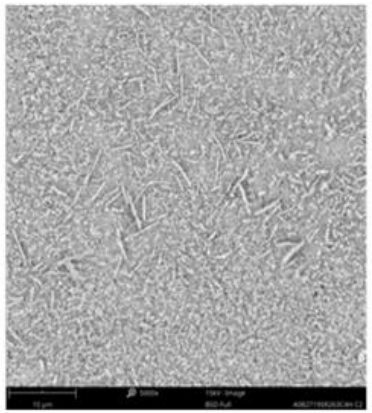
Core Technology: **Carbon Nanotube Metal Matrix Composites**

TechConnect DEFENSE INNOVATION AWARD 2020

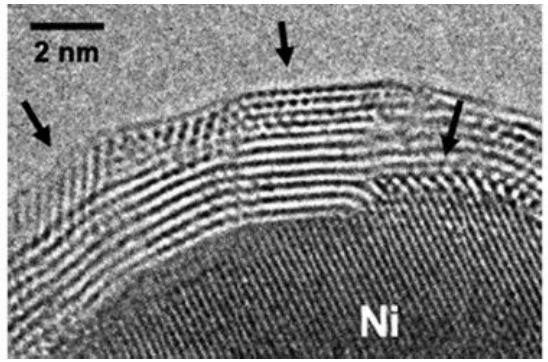
Carbon Nanotubes & Metal Powder



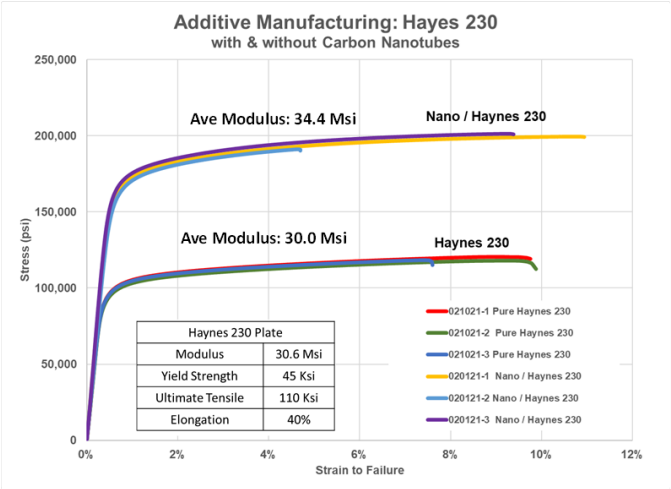
Additive Manufacturing



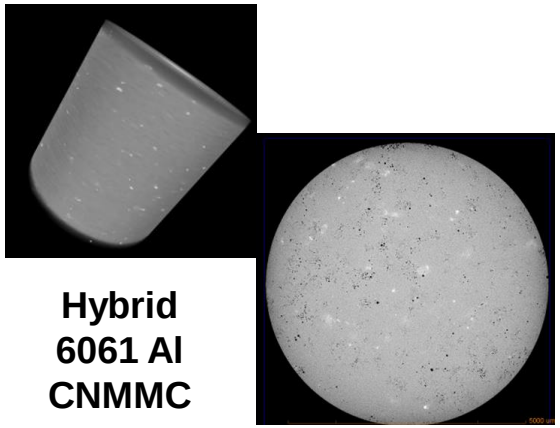
Two-phase Metal Matrix Composite



Hybridized electron bonding between carbon nanotubes & metal alloy

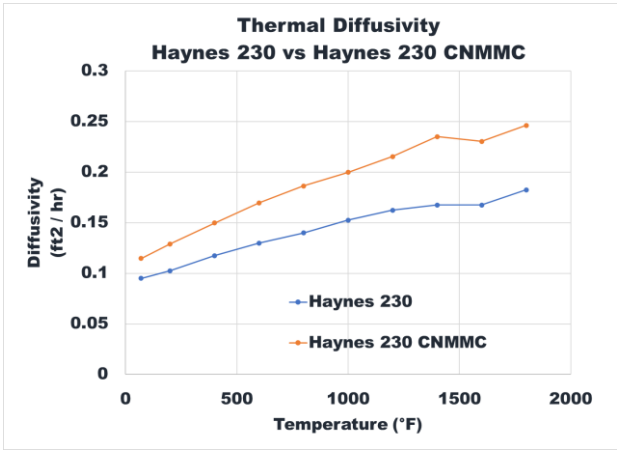


Increased Mechanical Properties

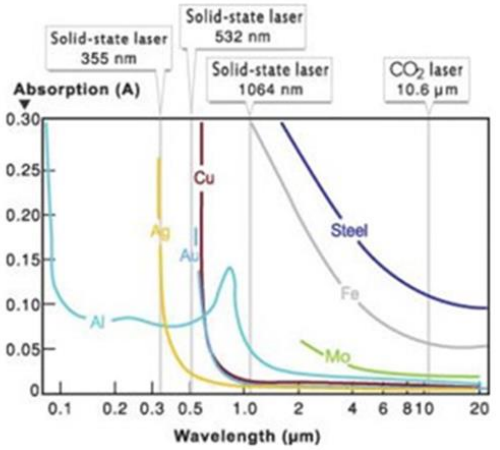


Hybrid 6061 Al CNMMC

Eliminate Solidification Cracking

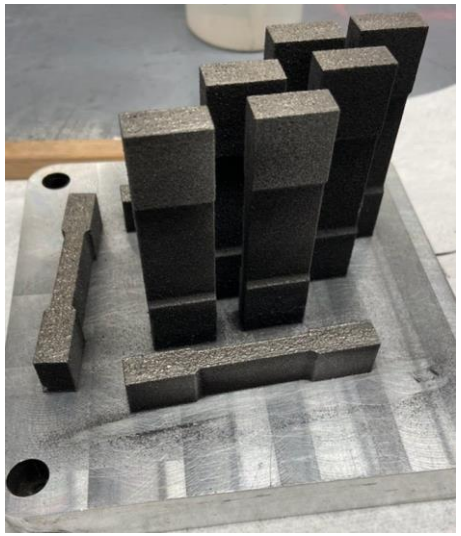


Increased Thermal Conductivity



Improved laser processing

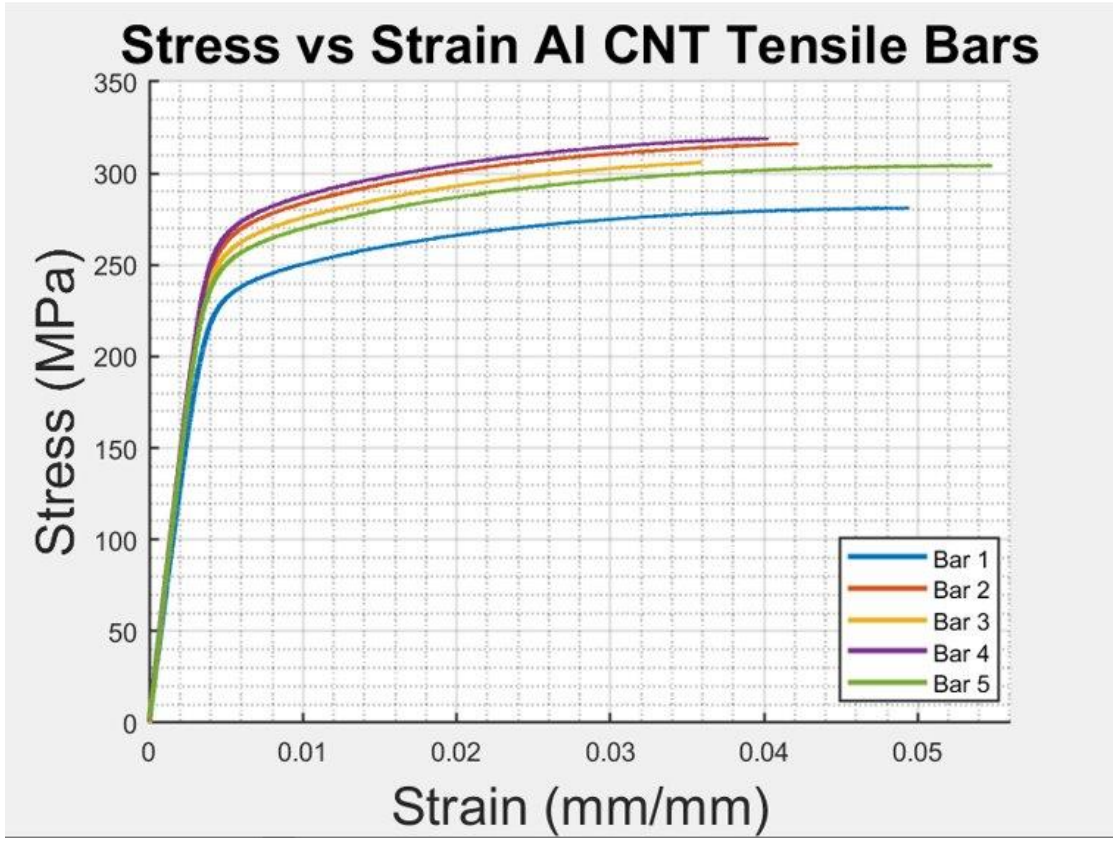
Air Force STTR 20D-TSC01: **6061 Aluminum**



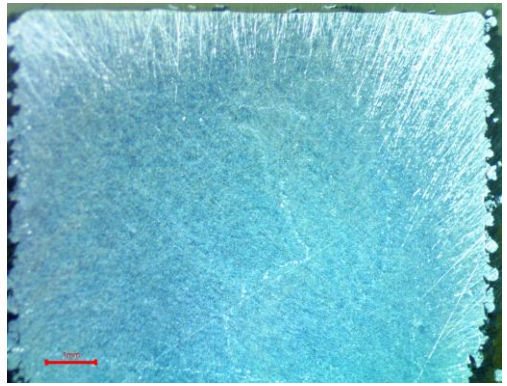
Application: Maintenance and Sustainment of 6061 aluminum components

Objective: Resolve solidification cracking, Achieve mechanical properties consistent with Mil-Handbook- 5 / MMPDS

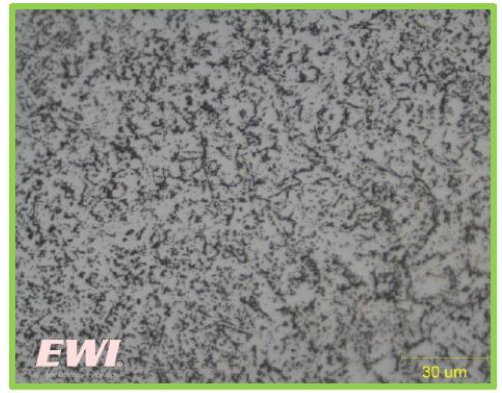
Result: Currently meeting requirements for yield strength and ultimate tensile strength. Just short on elongation to failure



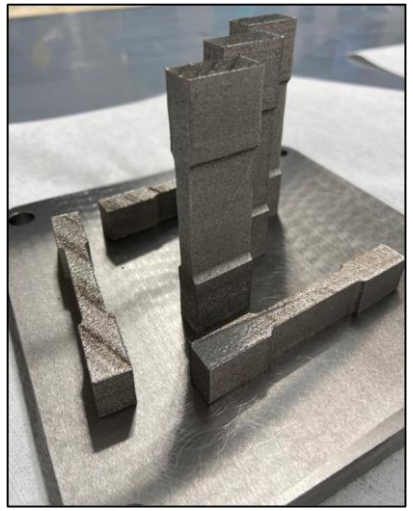
Next Steps: Finish post processing stress relief to improve mechanical properties, Obtain funding to do certification & qualification, Transition to SBIR 23.4-DSC01



Hybrid 6061 Aluminum & Carbon Nanotubes
> 99.7% dense



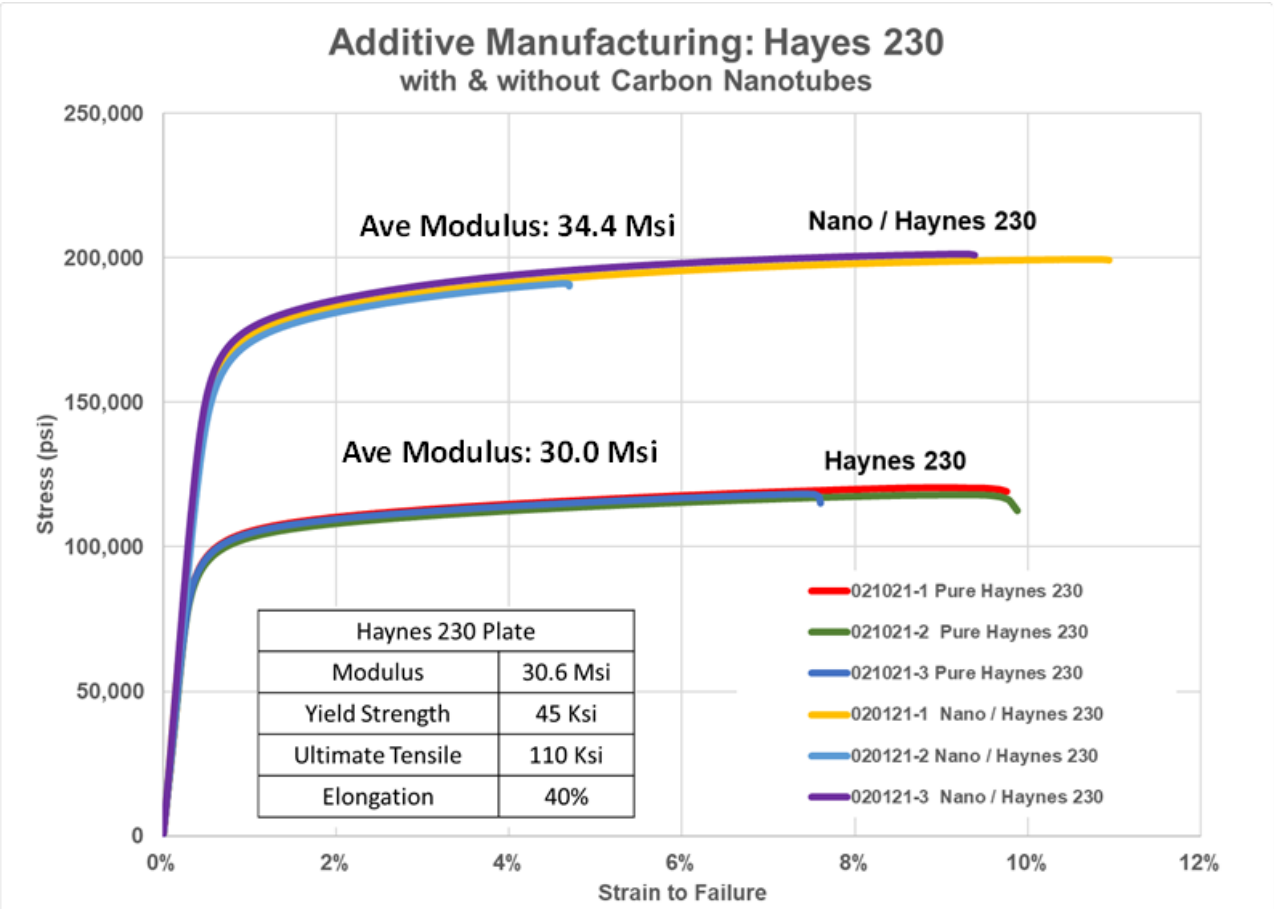
Air Force STTR 20D-TSC01: **Haynes 230**

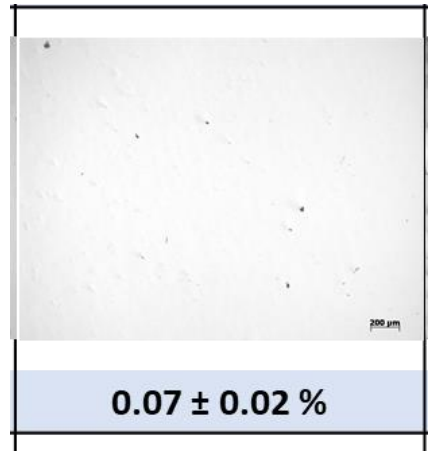


Application: Structural Hypersonic Thermal Protection System

Objective: Develop a high temperature structural material for Additive Manufacturing

Result: Current results have significant increases in strength, stiffness and thermal conductivity compared to traditional Haynes 230





Haynes 230 & Carbon Nanotubes
> 99.9% dense

Haynes 230 Sheet vs. DMLS Haynes 230 + Nano

Property	Sheet, RT	Nano	Percent Change
Yield Strength (ksi)	60	164 ± 2.0	▲ 173
Ultimate Strength (ksi)	124	197 ± 5.4	▲ 59
Fracture Strain (%)	47	8.3 ± 3.2	▼ 82
Hardness (HRB)	92	111 ± 0.2	▲ 21

Next Steps: Finish post processing stress relief to improve mechanical properties, Obtain funding to do certification & qualification, Transition to STTR 21B-TSC01 / SBIR 23.4 –DSC01