National Aeronautics and Space Administration

AM of High Permeability Magnetic Shielding Alloy (HIPERMASH)

Principal Investigator: Samad Firdosy (357); Co-Investigators: Nicholas Ury (357), Katherine Dang (513), Pablo Narvaez (513), Joshua Berman (343), Joelle Cooperrider (386), John Paul Borgonia (357), Bryan McEnerney (353), Vilupanur Ravi (346), Robert Dillon (357)

Program: FY21 R&TD Topics **Strategic Focus Area: Additive Manufacturing, Multifunctional Systems**

Objectives

The objective of this project was to establish a process for additive manufacturing and post-processing (surface finishing and heat treating) high permeability alloys (e.g. mu-metal) resulting in high shielding factors that will enable infusion into future JPL projects and missions. Specifically, the investigators planned to demonstrate the concept by utilizing two different AM processes (laser powder bed fusion (L-PBF) and direct energy deposition (DED)) to fabricate an AM version of the magnetic shielding concept for the Europa Clipper Reaction Wheel Assembly (RWA) Wheel Unit. In addition, metallurgical gradients were to be evaluated towards optimization of magnetic shielding for reduced mass, elimination of fasteners and enhancement of shielding factors through fabrication of multi-material monolithic structures.

Background

High permeability magnetic materials used for magnetic shielding in JPL spacecraft can be challenging to fabricate and iteratively design (such as with the ferrite shields for JUNO) and can be time consuming and costly. Due to the difficultly in processing these materials, the resultant shields were difficult to design (due to the limited time available for iteration), geometrically simple, and not optimized for integration. More recently, electro-magnetic compatibility testing for Europa Clipper reaction wheel assembly components has shown that there is a high probability of not meeting magnetic requirements and, therefore, necessitating the use of magnetic shieling. Designing in complexity using the current manufacturing approach for state-of-the-art magnetic shields comes with significant cost and schedule. With AM, complexity is almost free and thus the design space can be expanded to include potentially more effective shields with lower mass than could otherwise be manufactured today.

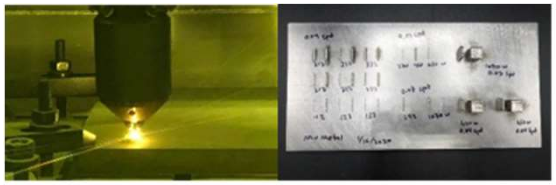
Significance/Benefits to JPL and NASA

Typically, magnetically shielding is avoided if at all possible due to complexity and long development efforts to add on shielding to existing qualified component designs. HIPERMASH would provide for quick development and present Cognizant Engineers with more options when designing with EMC in mind. In addition, a novel method of fabricating multi-material, monolithic shields with alternating walls of high saturation and high permeability alloys was developed and shown to provide nearly an order of magnitude enhancement in shield attenuation performance compared to single alloy shields. This technology may be leveraged to design and manufacture shields which are highly optimized for mass savings and shield attenuation. Any future project with a magnetically susceptible scientific instrument (e.g. magnetometer) and components with magnetic emissions (e.g. Reaction Wheels) could implement HIPERMASH.

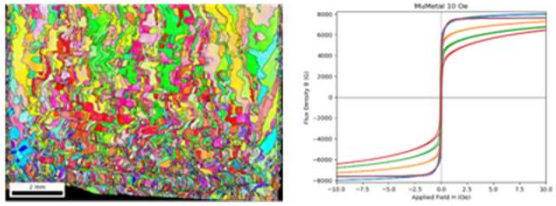
National Aeronautics and Space Administration
Jet Propulsion Laboratory
California Institute of Technology
Pasadena, California

www.nasa.gov

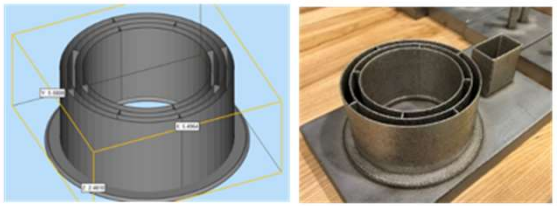
Approach



Print Parameter and Post Process Development



Material / Magnetic Properties

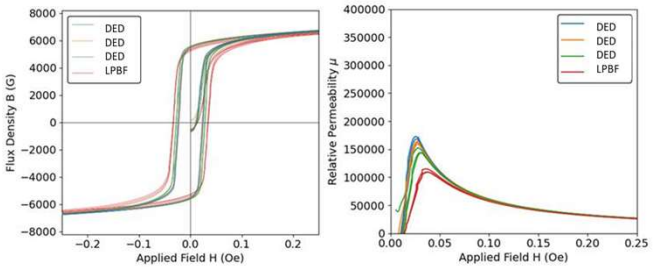


Rapid Build / Test Prototype

AM process development approach using Carpenter Hymu80 (Fe-80Ni-5Mo) feedstock powder

PI/Task Mgr Contact
Email: Samad.A.Firdosy@jpl.nasa.gov

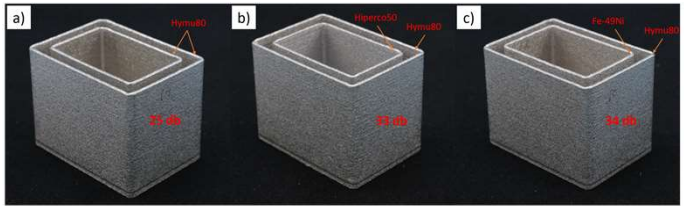
Results



Magnetic hysteresis measurements for AM printed coupons and annealed show permeabilities in excess of 100,000 and coercivities as low as 0.025 Oe

Test Article	Shielding Effectiveness (dB)
AM Box Shield	-18
Wrought box shield	-17
Double Wall RWA Shield	-27
Triple Wall RWA shield	-33

Shielding effectiveness of AM shields is comparable to traditionally manufactured shields



Multi-material AM shields that incorporate both high permeability and high saturation alloys in a monolithic component show 8-9 db improvement in shielding effectiveness compared to single alloy AM shield

Clearance Number:
RPC/JPL Task Number: R20124