Virtual Research Presentation Conference

Low Density Invar

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Program: SURP

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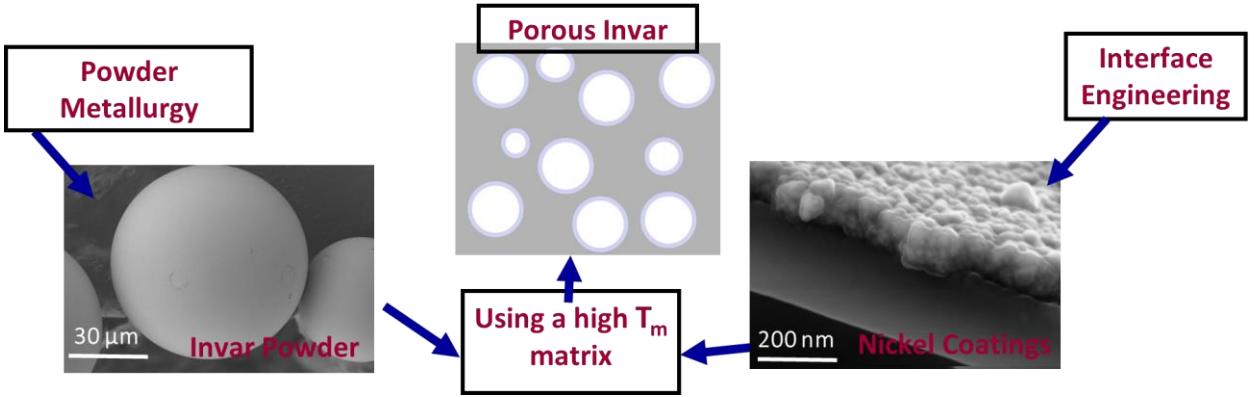
Tutorial Introduction

Abstract

The objective of this research is to develop an Invar composite (Invar + glass microspheres) with at least 30% lower density but similar, if not better, coefficient of thermal expansion (CTE) behavior compared to monolithic Invar. JPL often uses Invar in its optics systems where temperature stability is key. Unfortunately, it has a density of 8.0 g/cm^3, similar to steel and nickel alloys. These are all significantly higher than aluminum (~2.7 g/cm^3) and titanium (4.4 g/cm^3) alloys, but both of their CTEs are relatively high. In order to aid in bonding between the glass microspheres and Invar matrix, the microspheres will be nickel plated in solution. Their mechanical properties will be measured with micro-compression tests to determine appropriate processing parameters. Finally, Invar powder and the coated glass microspheres will be hot pressed together to for billets of low density Invar.



Problem Description

a) Context (Why this problem and why now)
   a) Invar is ubiquitous for use in systems needing to stay dimensionally stable across large temperatures, but it has to be judiciously used due to its relatively high density.
   b) Research in the literature has shown the ability to form low density foam alloys by co-casting molten metals with hollow glass microspheres

b) SOA (Comparison or advancement over current state-of-the-art)
   a) We will grow the idea of co-casting metals with glass microspheres by instead using techniques from powder metallurgy to create low-density alloys with high melting temperatures. This technique can then likely be extended to all sorts of nickel and iron-based alloy systems
   b) Porous Invar structure will be lower density than Si_3N_4 created by NASA Goddard (LoVAR).

c) Relevance to NASA and JPL (Impact on current or future programs)
   a) Will give JPL the lowest density Invar variant, with likely the lowest coefficient of thermal expansion.
   b) Enable greater use of Invar across missions
   c) Can lead to other possible useful materials; porous titanium for Venus atmospheric probe, low density steels for Icy Moon landers, etc

Methodology

a) Formulation, theory or experiment description

a) Build a hot pressing system to heat powder using an RF power supply and apply pressure with a hydraulic press

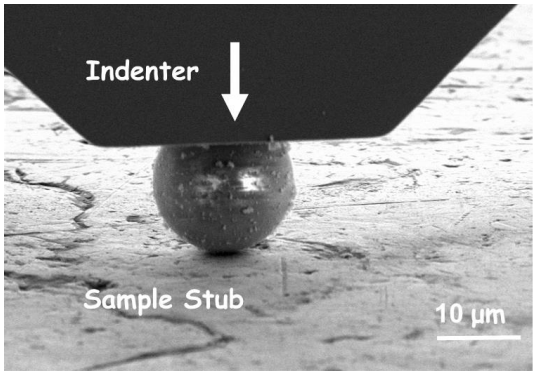
b) Perform a series of experiments to optimize nickel coating of glass microspheres, existing techniques do not provide solid, uniform coatings or contain other inclusions.

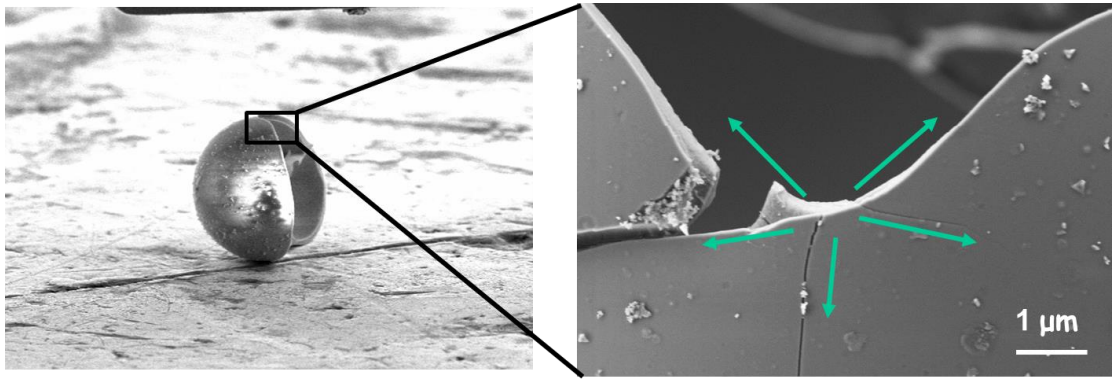
c) Characterize mechanical properties of microspheres to more efficiently probe process map of time, temperature, and pressure.

d) Perform hot pressing experiments with microspheres to make consolidated billets

e) Characterize thermal expansion, mechanical properties, and thermal stability of porous Invar structure

b) Innovation, advancement





Results

a) Accomplishments versus goals

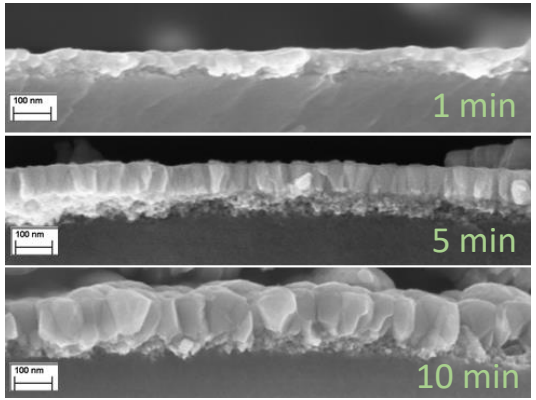
- a) Build a hot pressing system to heat powder using an RF power supply and apply pressure with a hydraulic press
- b) Perform a series of experiments to optimize nickel coating of glass microspheres, existing techniques do not provide solid, uniform coatings or contain other inclusions.
- c) Characterize mechanical properties of microspheres to more efficiently probe process map of time, temperature, and pressure.
- d) Perform hot pressing experiments with microspheres to make consolidated billets
- e) Characterize thermal expansion, mechanical properties, and thermal stability of porous Invar structure

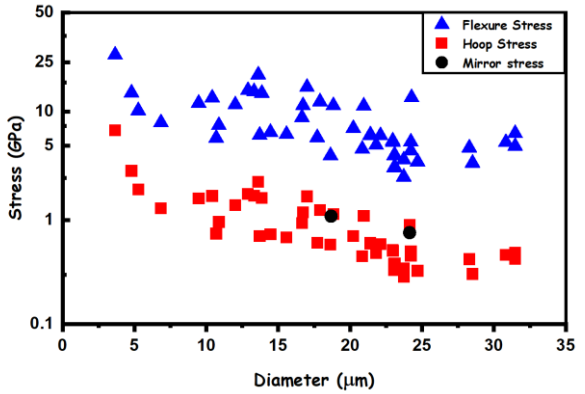
b) Significance

- a) High quality nickel coatings of glass microspheres achieved. Can do parallel projects with other alloys of interest if there is interest.

c) Next steps

- a) Project is a little behind schedule due to SARS-CoV-2 laboratory shutdowns. Allowed for accelerated preparation of paper, but laboratory work is behind schedule.
- b) Initial hot pressing steps have begun, should be completed within a few months





Publications and References

Conference Talk:

- *"Processing and Microstructural Characterization of Novel Invar Syntactic Foams"* Justin Whetten, Arun Sundar, Jason Williams, Scott Roberts, Nikhilesh Chawla. TMS 2020 Annual Meeting Feb 25th 2020

Paper in Preparation

- *"Properties of Nickel Coated Hollow Glass Microspheres."* Justin Whetten, Scott Roberts, Nikhilesh Chawla