Physical and Mechanical Properties of LoVAR: a new lightweight particle-reinforced Fe-36Ni alloy

Timothy Stephenson, NASA Goddard Space Flight Center, Greenbelt, MD, USA
David Tricker, Andrew Tarrant, Materion AMC, Farnborough, Hampshire, UK
Robert Michel, Jason Clune, Materion Beryllium and Composites, Elmore, OH, USA

SPIE Optics + Photonics 2015
San Diego, CA
August 9 – 13, 2015

GODDARD SPACE FLIGHT CENTER

MATERION

Agenda

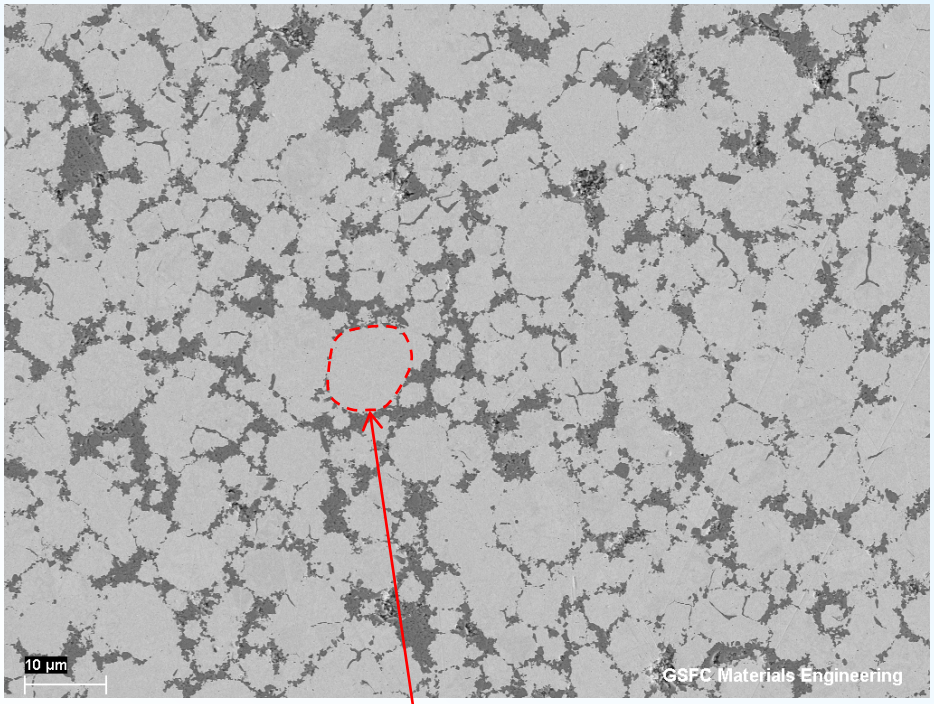
- Background
- Initial Trials
- Process Route
- Mechanical & Physical Properties
- Summary

Background

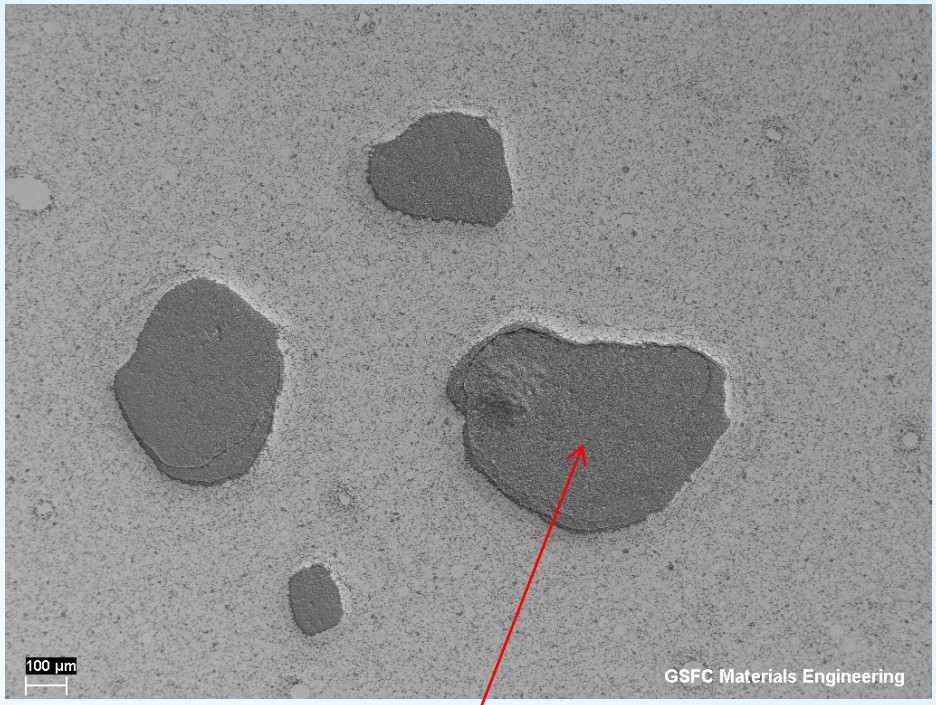
- Because of its low thermal expansion, alloy Fe-36Ni finds extensive use in spacecraft structures that require high pointing accuracy and dimensional stability, in spite of its density (8.1g/cm^3).
- For Example:
  - JWST uses 429kg
  - Kepler FPA 20kg
- However, Payload mass is a direct driver of launch cost!

- So there is a direct need to light-weight this alloy while maintaining its favourable low-expansion properties.

Initial Blending Trials
Fe-36Ni+20Si_3N_4



Necklacing of Si_3N_4 around Fe-36Ni powders



Agglomeration of Si_3N_4 to produce millimeter sized agglomerates

Process Route

Processing ⟷ Structure ⟷ Properties ⟷ Performance

- Fe-36Ni Powder
- Si_3N_4 Powder

Raw Materials

- Mixing
- Mechanical Alloying

High Energy Mixing

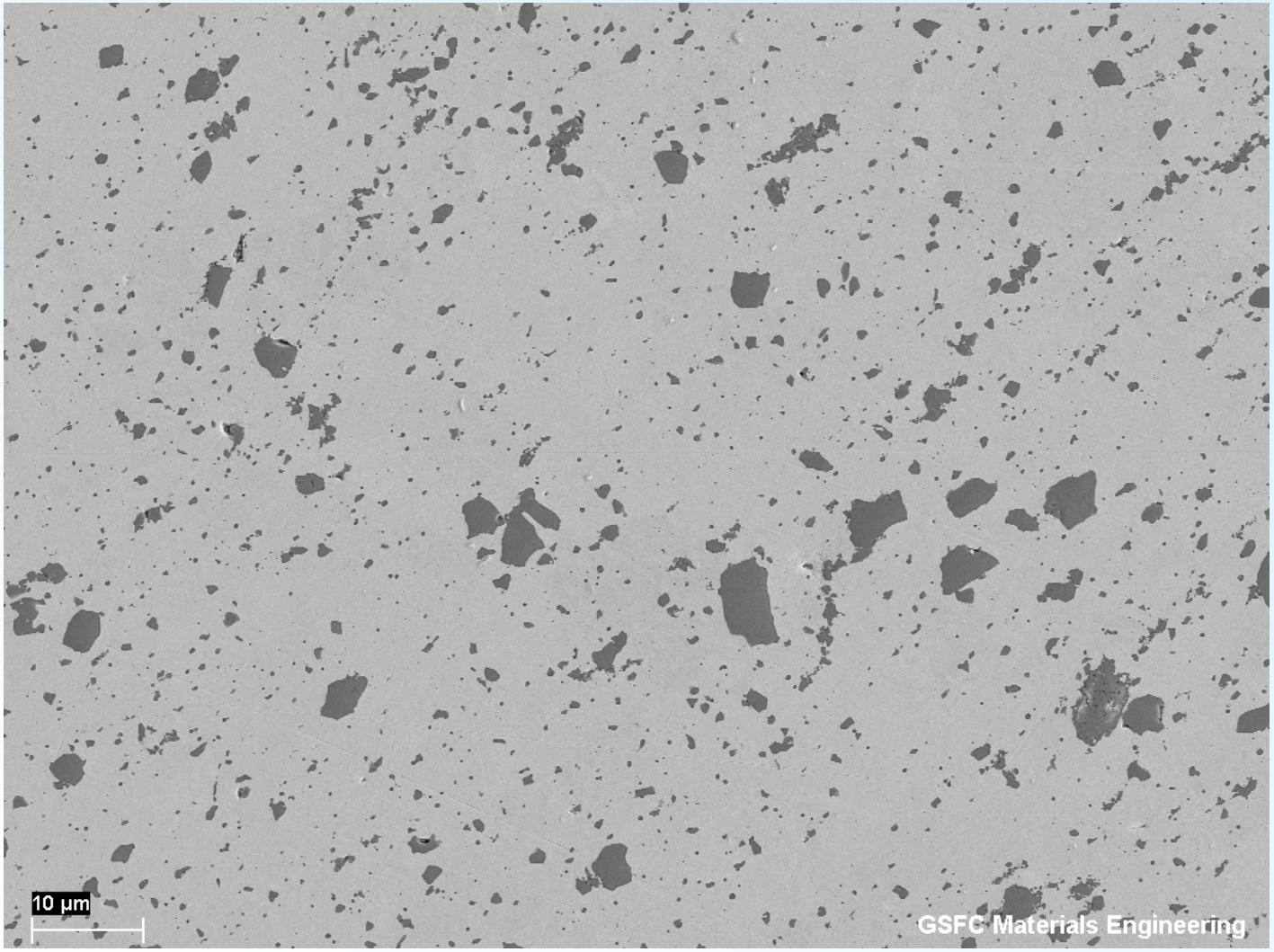
- Hot Isostatic Pressing

Solid-State Compaction

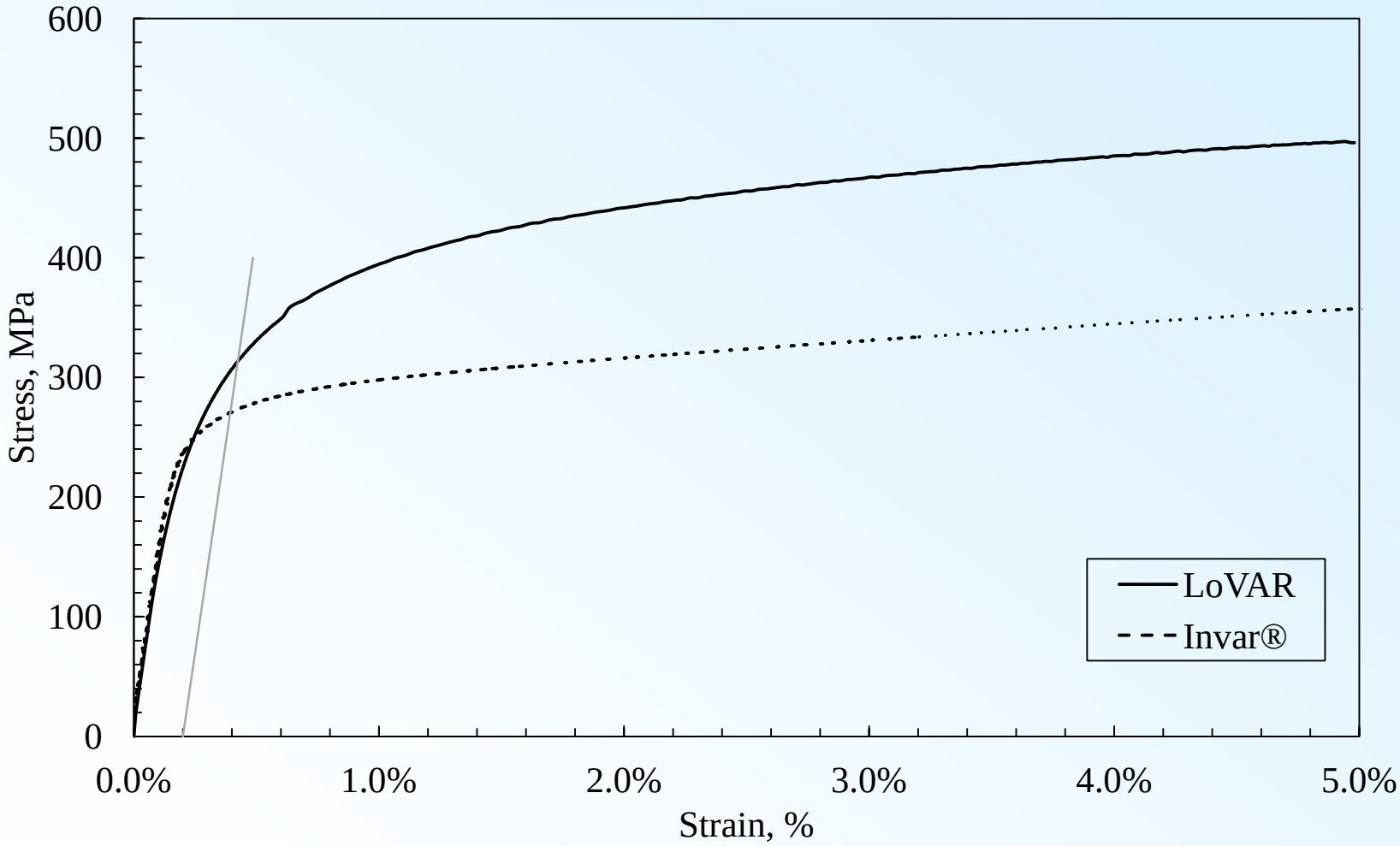
- Open Die Forging

Secondary Processing

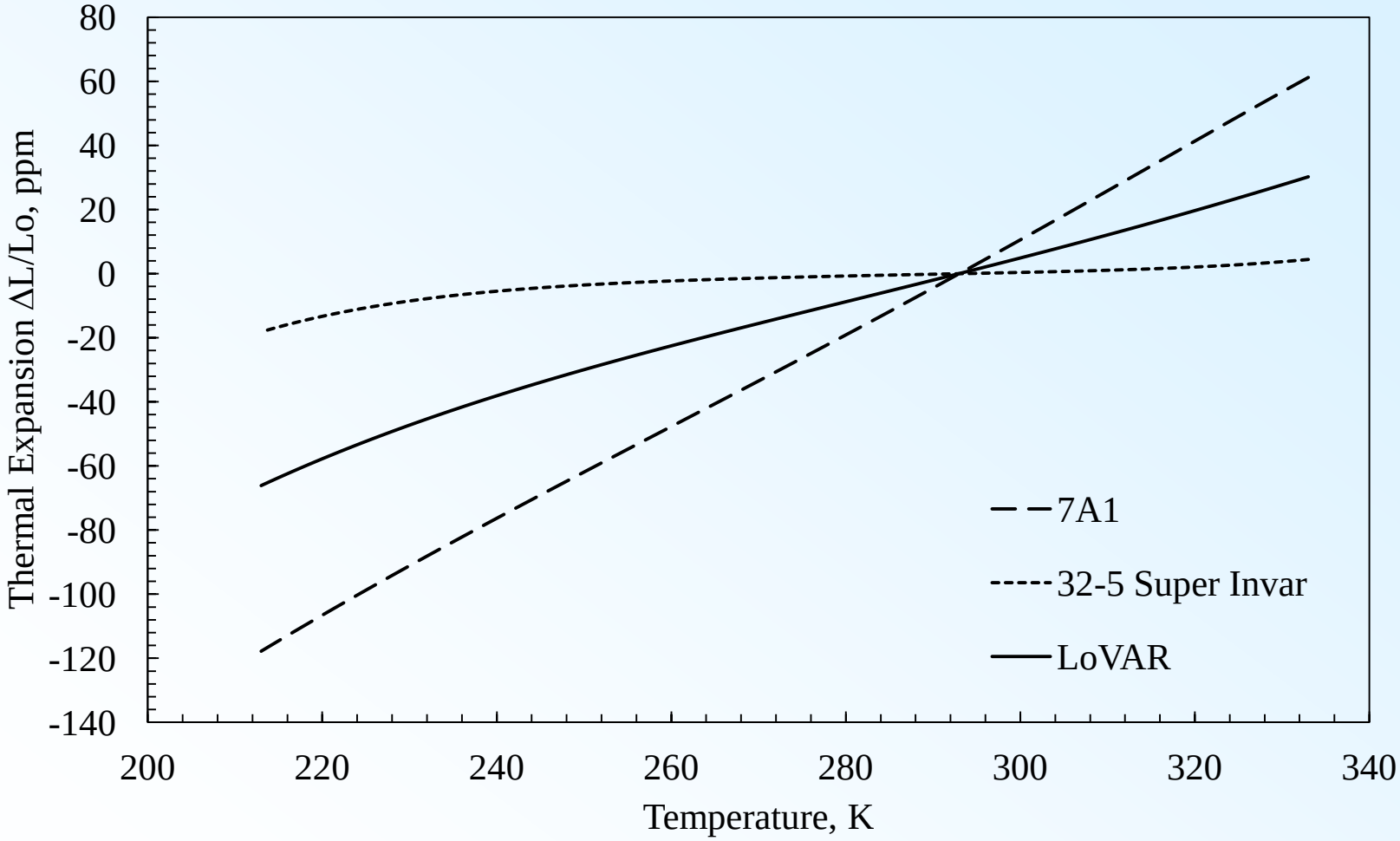
Mechanically Alloyed Fe-36Ni+20Si_3N_4



Tensile Properties



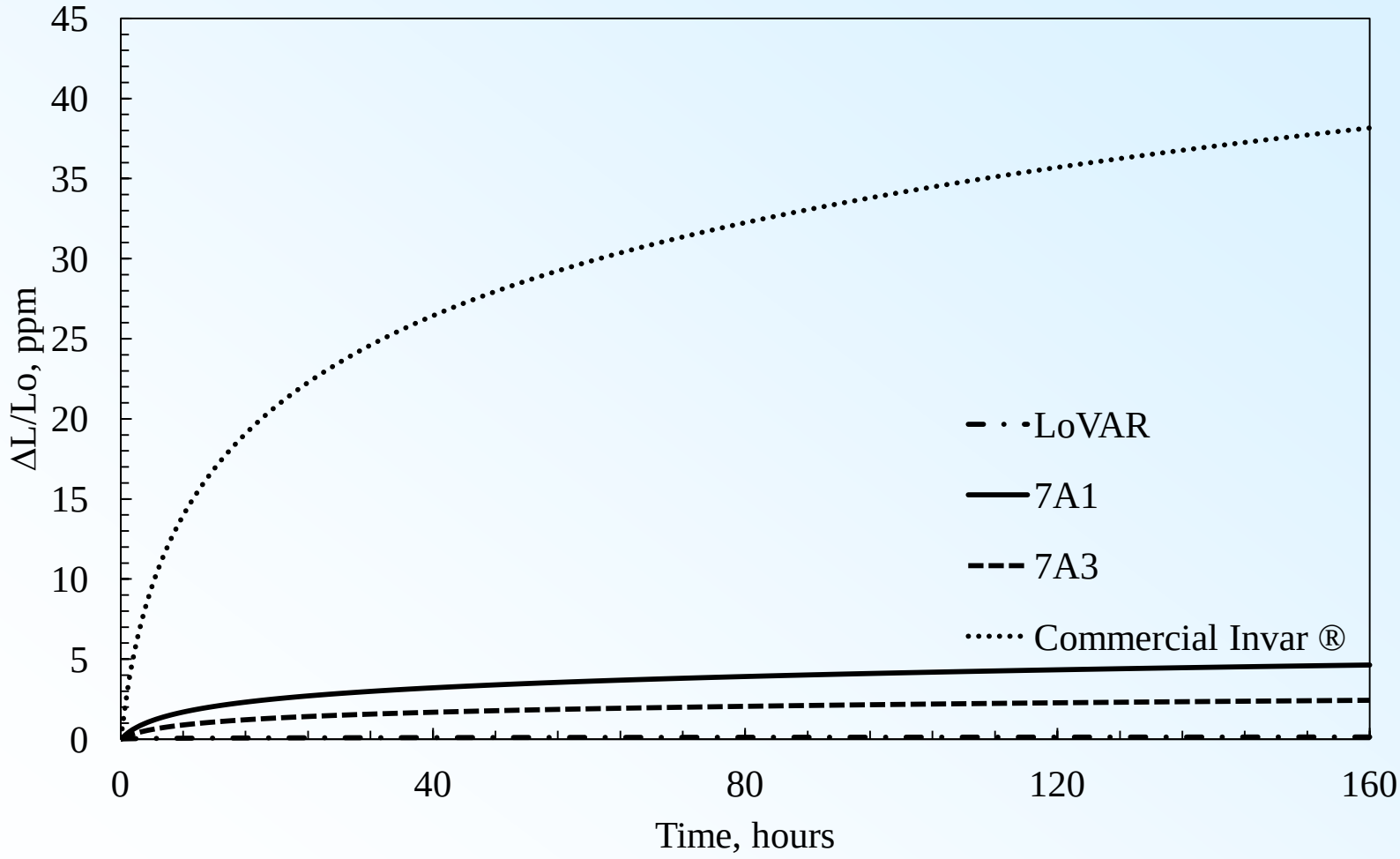
Thermal Expansion



Secant CTE

Alloy	Room Temperature CTE (ppm/K)	Secant CTE 10°C to 30°C (ppm/K)	Secant CTE -60°C to 60°C (ppm/K)
LoVAR	0.69	0.69	0.80
Super-Invar	0.05	0.06	0.19
Invar® (7A1)	1.49	1.49	1.49

Isothermal Dimensional Stability at 80°C



Isothermal Dimensional Stability at 80°C

Sample ID	Dimensional Change (ppm)
LoVAR	0.14
Invar ® (7A1)	4.65
Invar ® (7A3)	2.42
Invar ® (commercial hot finished rod)	38.16

Note: LoVAR greatly reduces the isothermal time-dependent length change that has been one of the main difficulties using Invar® in optical structures.

Summary

- We have described the early stage development of a new MMC that we call LoVAR.
- It embodies a low CTE and excellent dimensional stability.
- Materion and GSFC will continue to exploit the alloy design paradigm:

Processing ⟷ Structure ⟷ Properties ⟷ Performance

To further enhance specific stiffness and stability.

- This will include a CTE matching capability.