Amorphous Metals Technology

DARPA

BOEING

McGill

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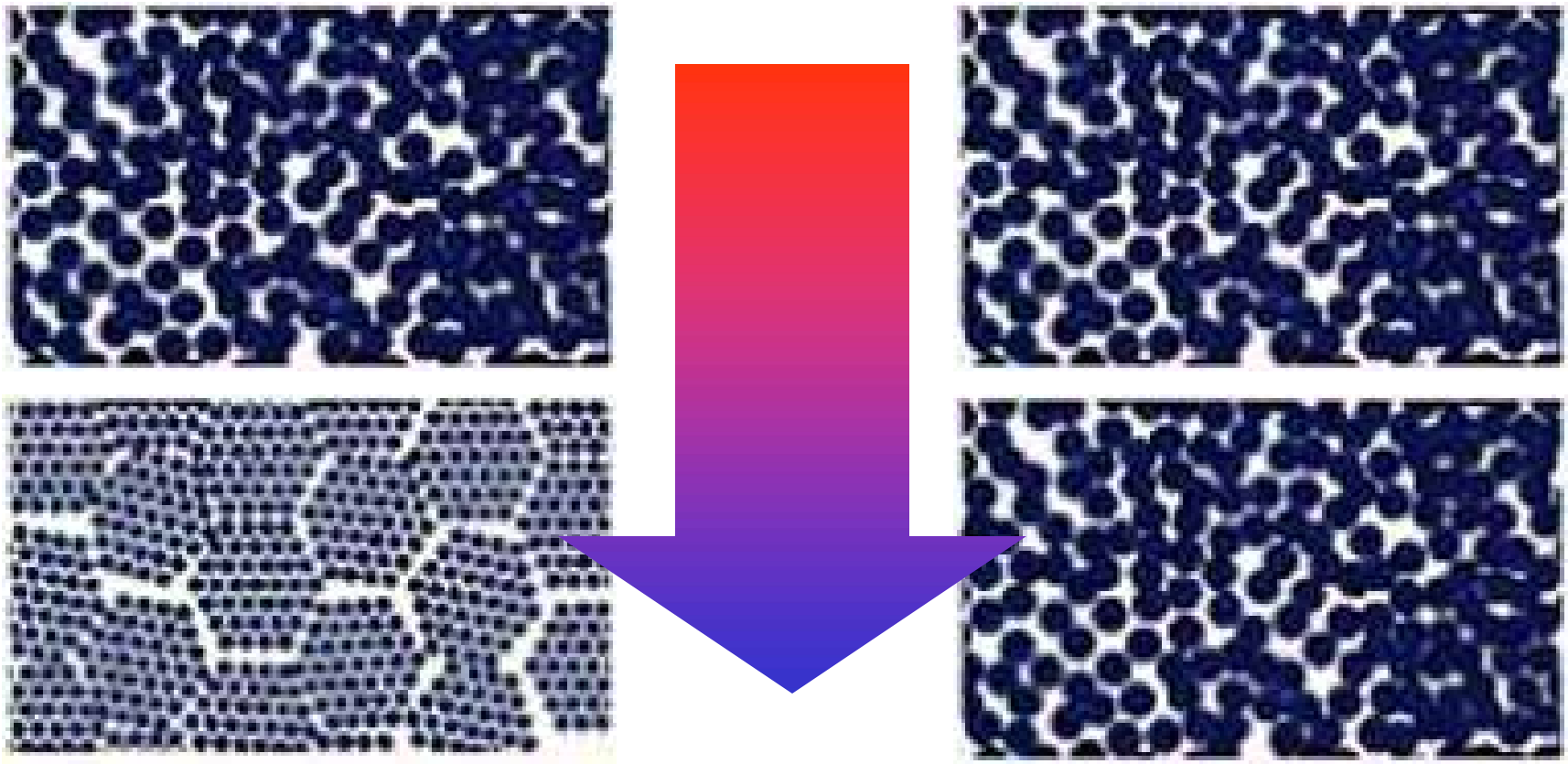
What Is an Amorphous Metal?



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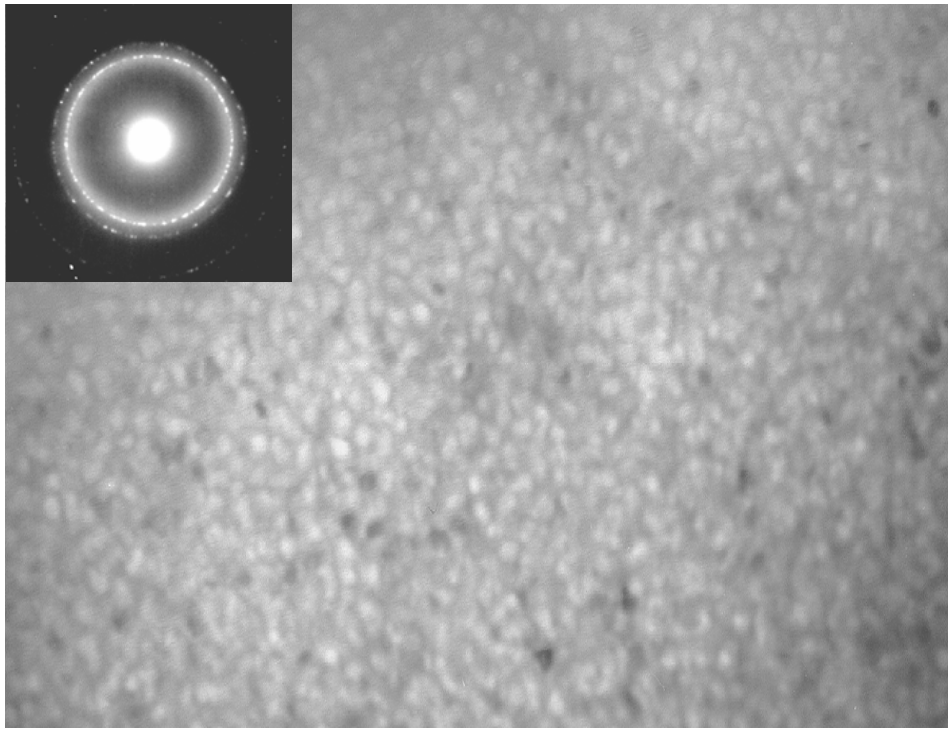
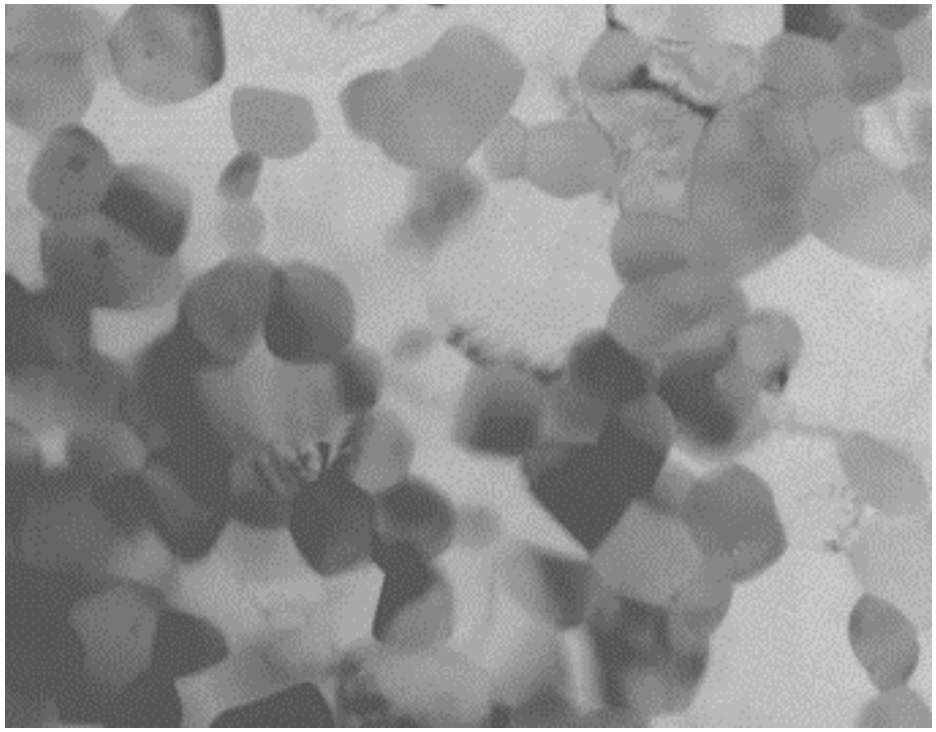
Pathway to Nanostructured Metals





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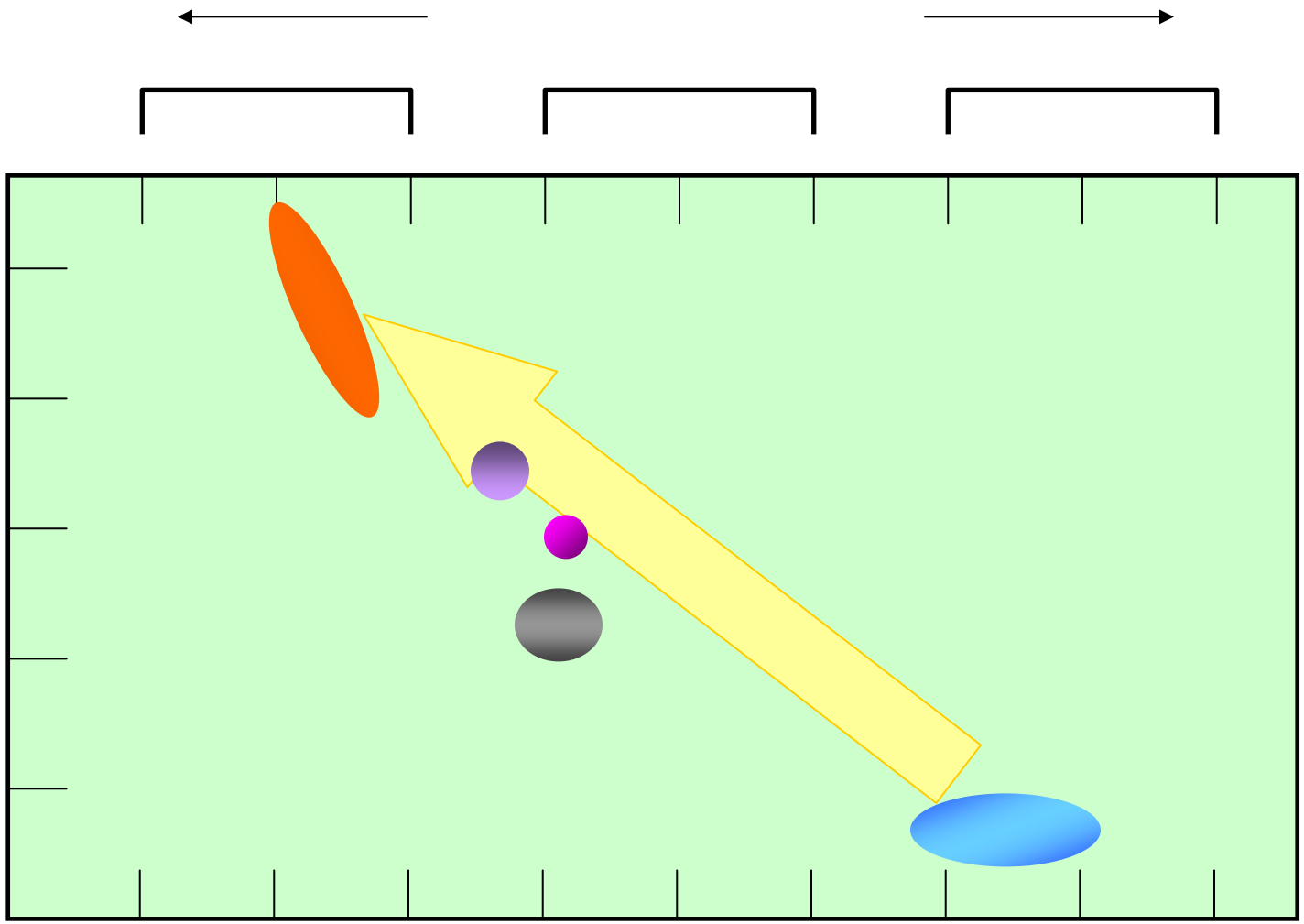
Influence of Microstructural Scale



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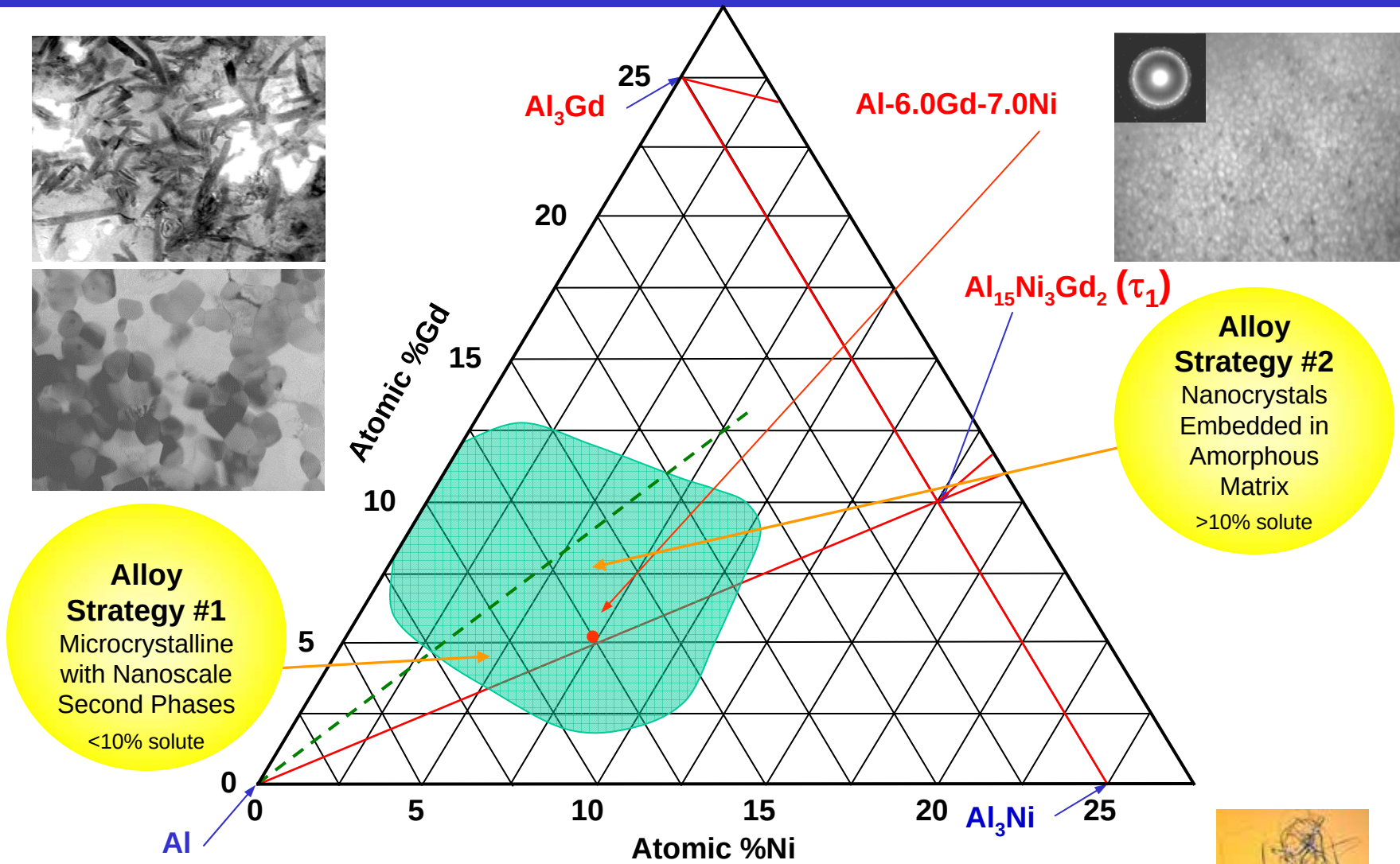
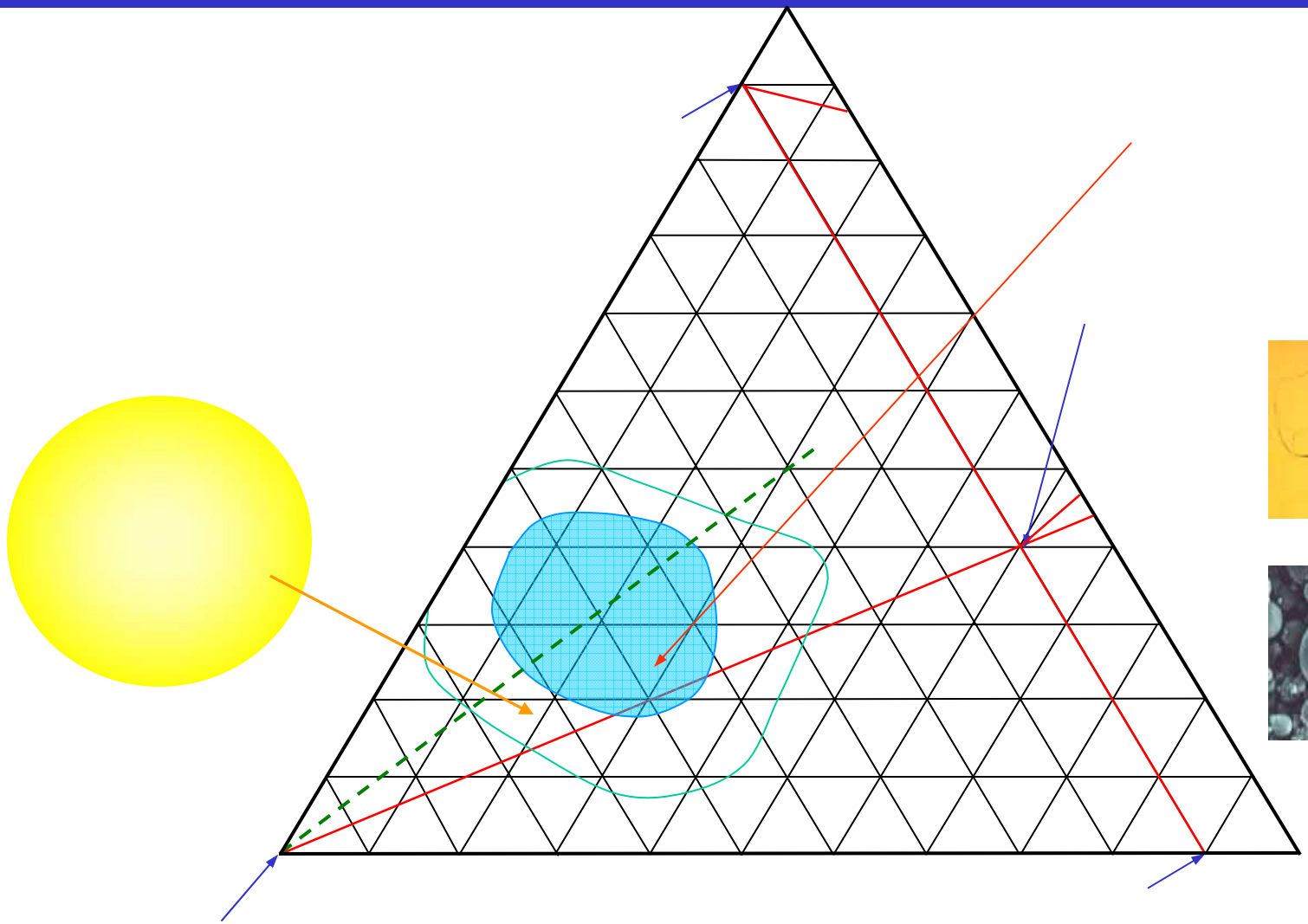
Program Objectives

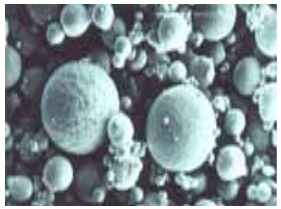
Strategies for Alloy Development



Data from Melt-spun Ribbons

Al-TM-RE Type System





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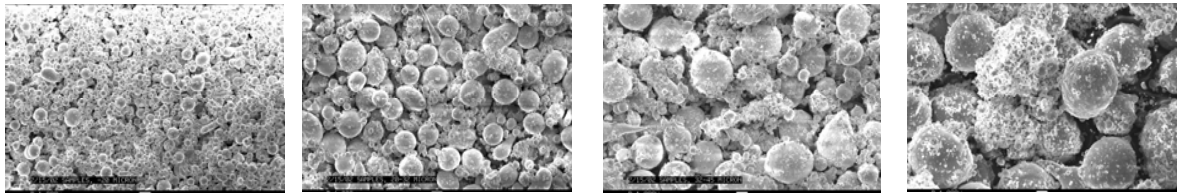
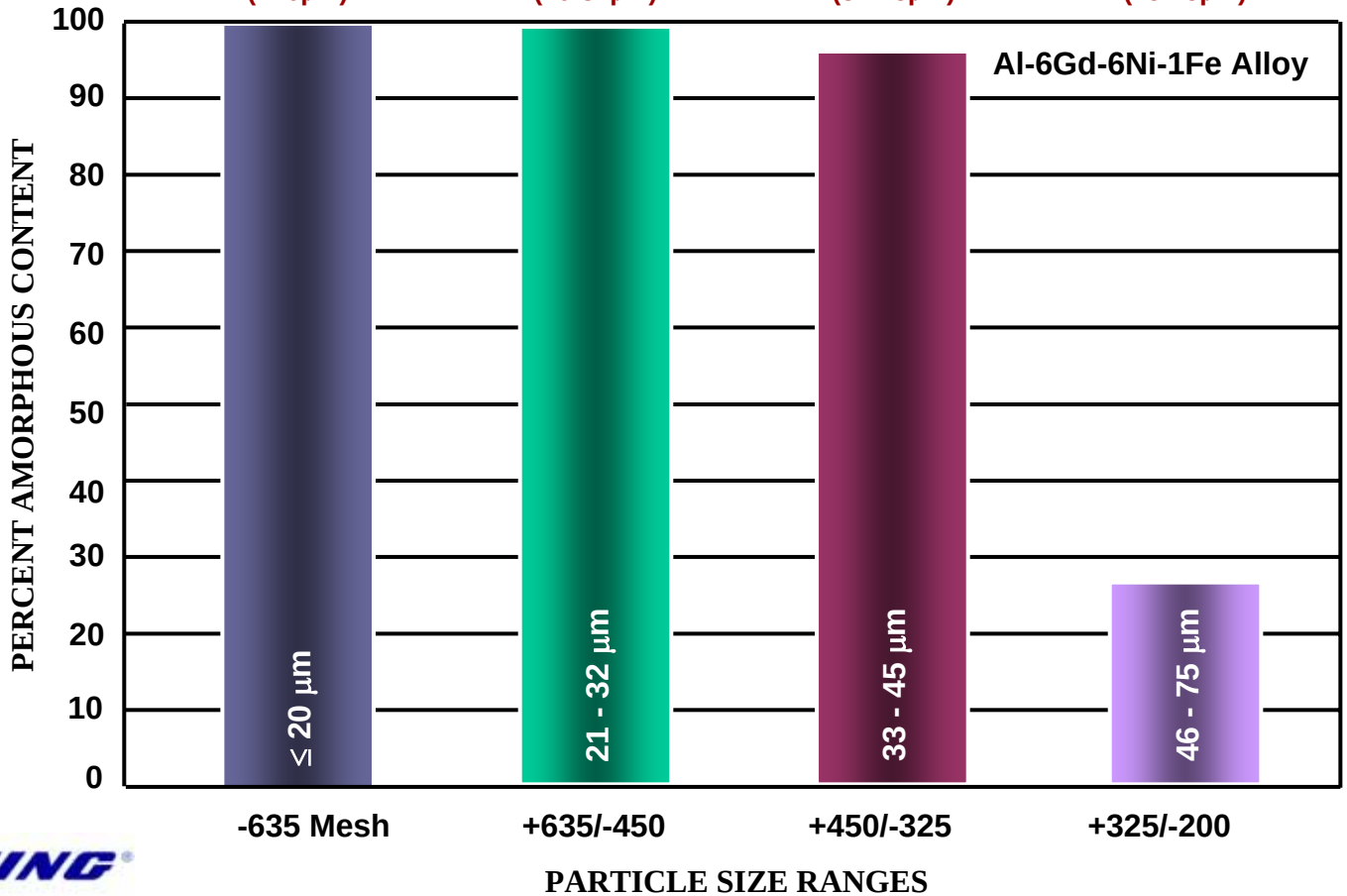
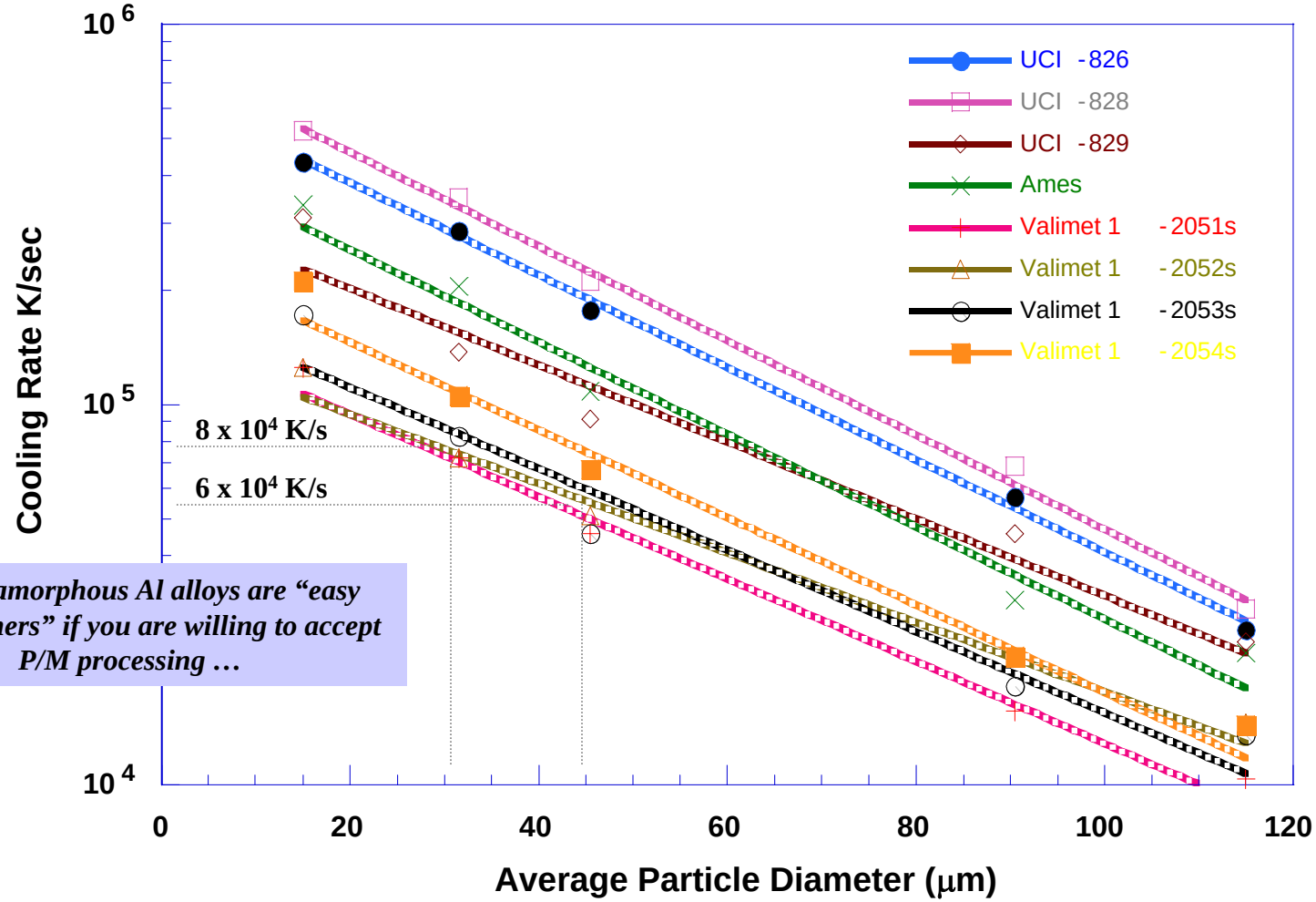
Gas-Atomized Amorphous Powder



-635 Mesh (<20µm) | +635/-400 Mesh (20-32µm) | +450/-325 Mesh (32-45µm) | +325/-200 Mesh (45-75µm)



Critical Cooling Rate



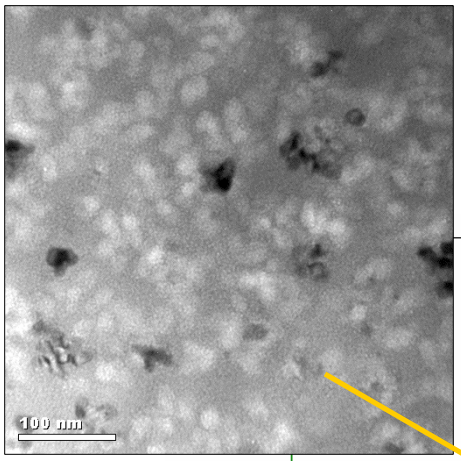
Known amorphous Al alloys are "easy glass formers" if you are willing to accept P/M processing …

-635	+635 / -450	+450 / -325	+325 / -200

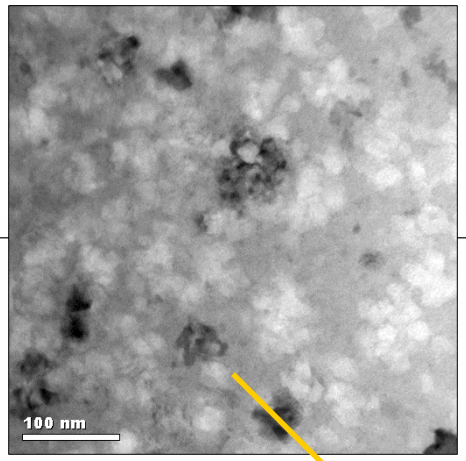
Mesh Size

DSC Analysis of Devitrification

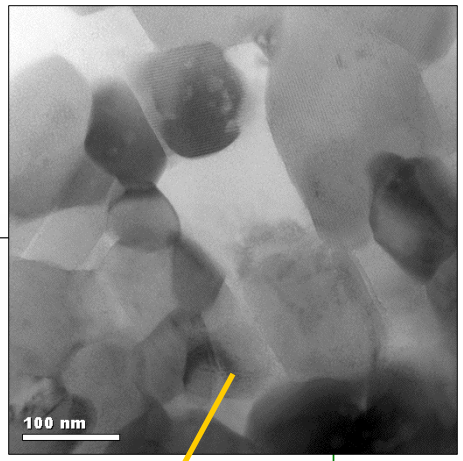
Heated to 600°F (315°C)
Beyond 1st Peak

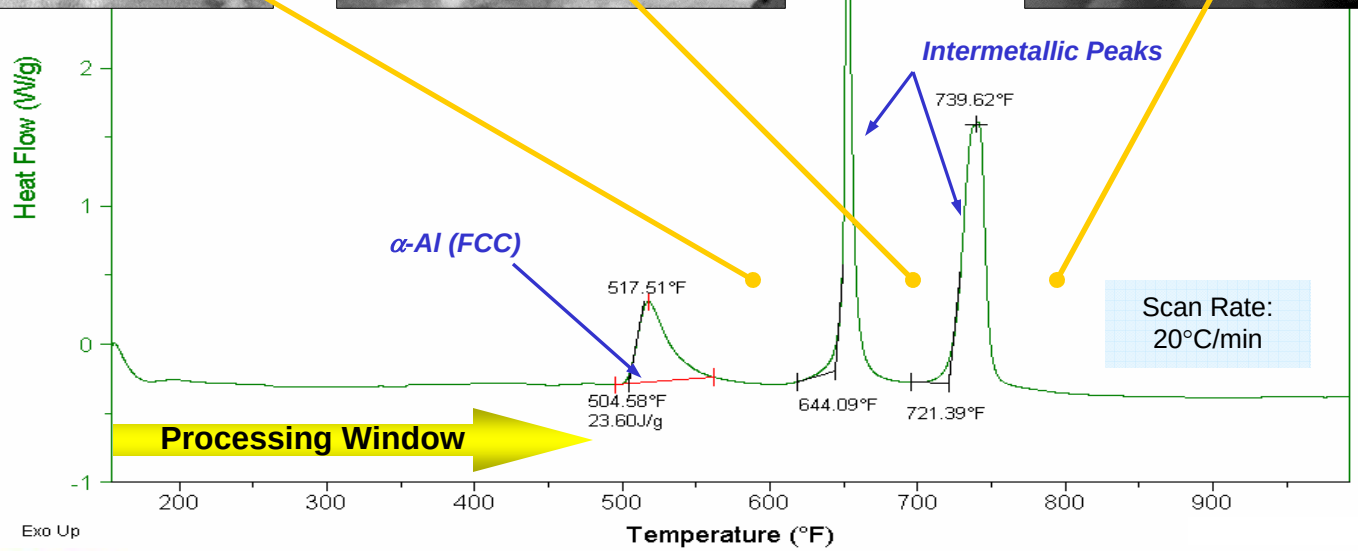


Heated to 680°F (377°C)
Beyond 2nd Peak



Heated to 800°F (427°C)
Beyond 3rd Peak



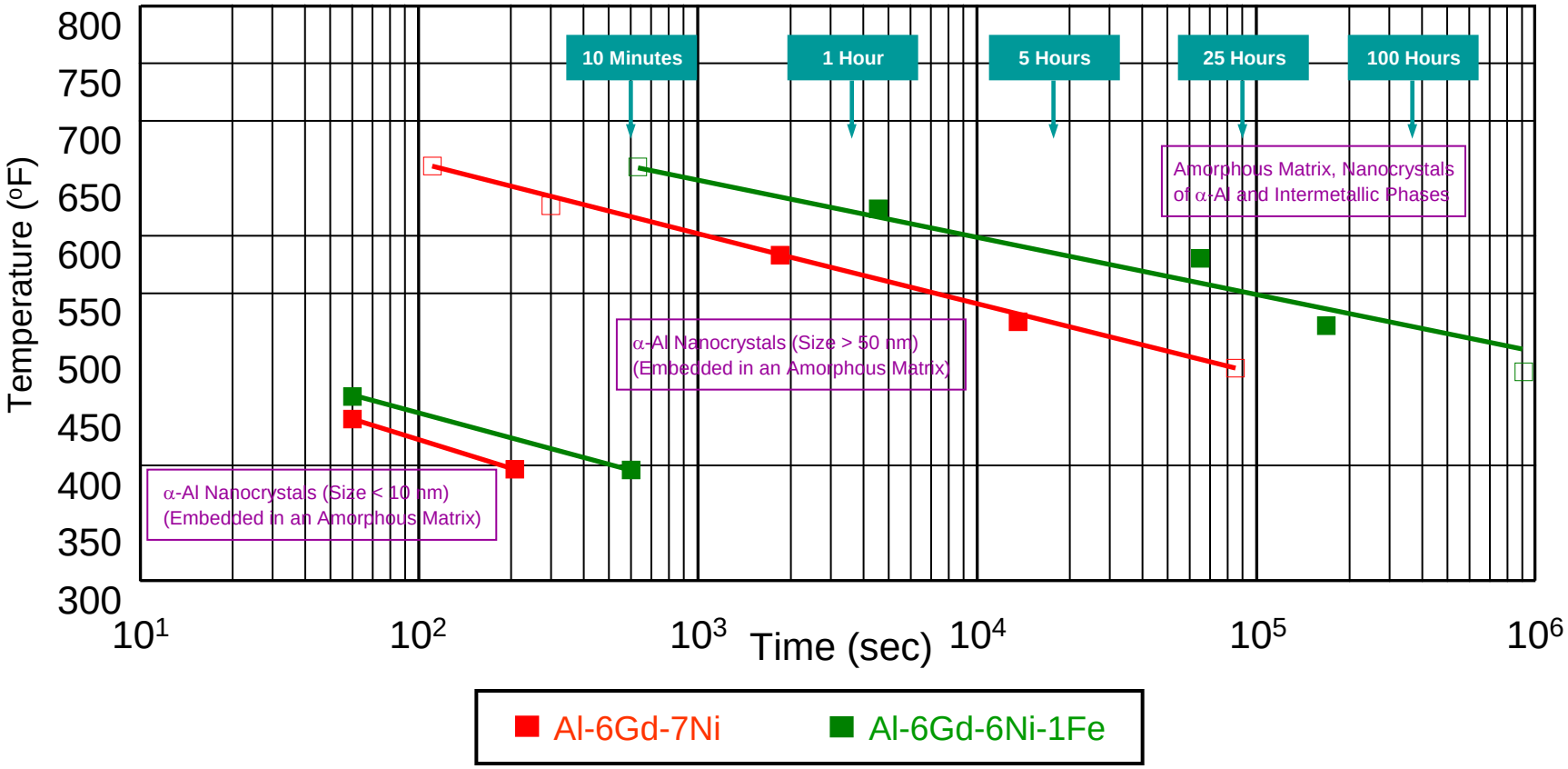


Al-5.1Y-7.7Ni-2.2Co-1.1Fe

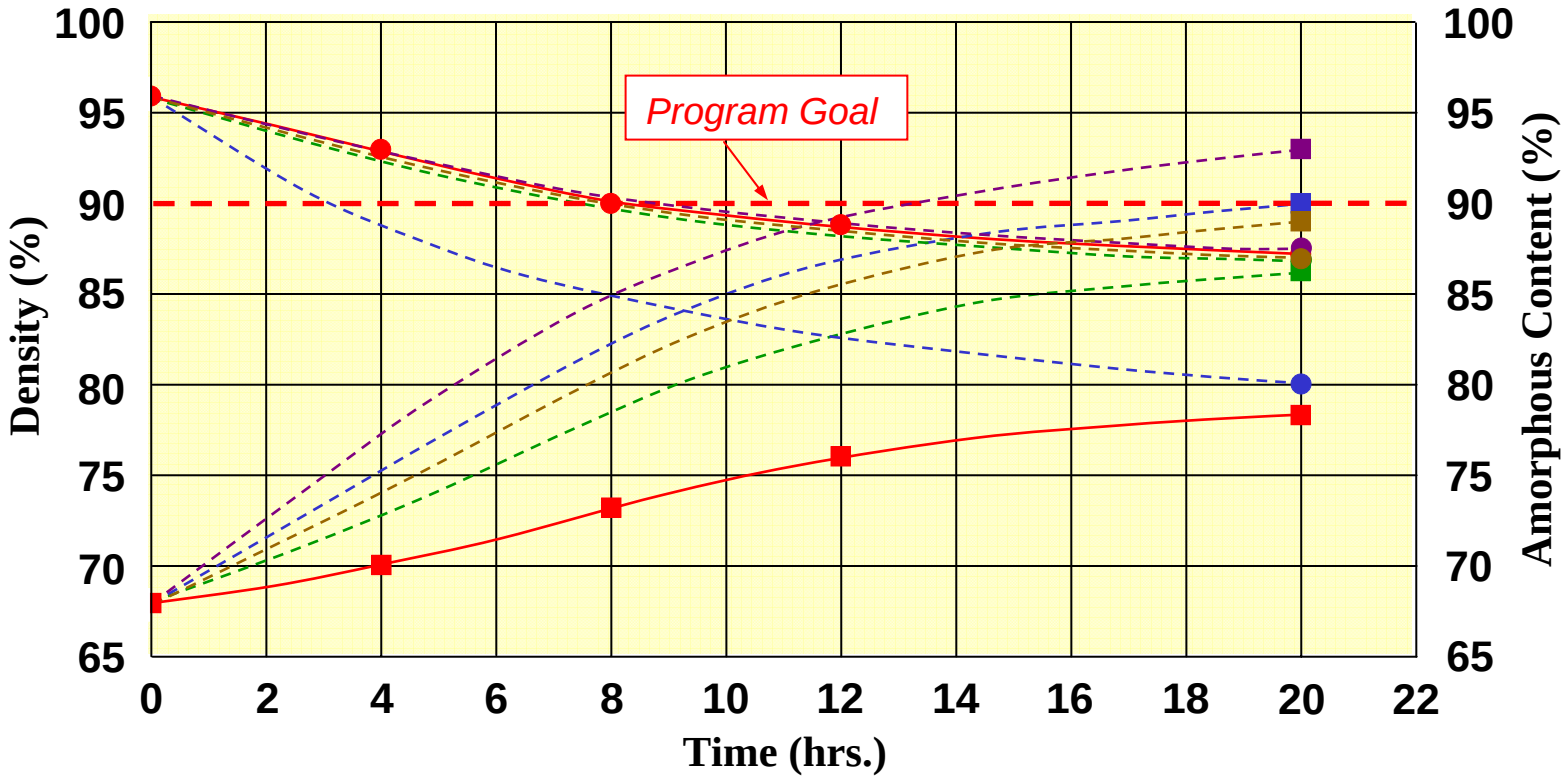
Processing Maps for Consolidation

Alloying Can Be Used to Expand the Processing Window

Time-Temperature Parameters for Processing



Powder Consolidation by VHP



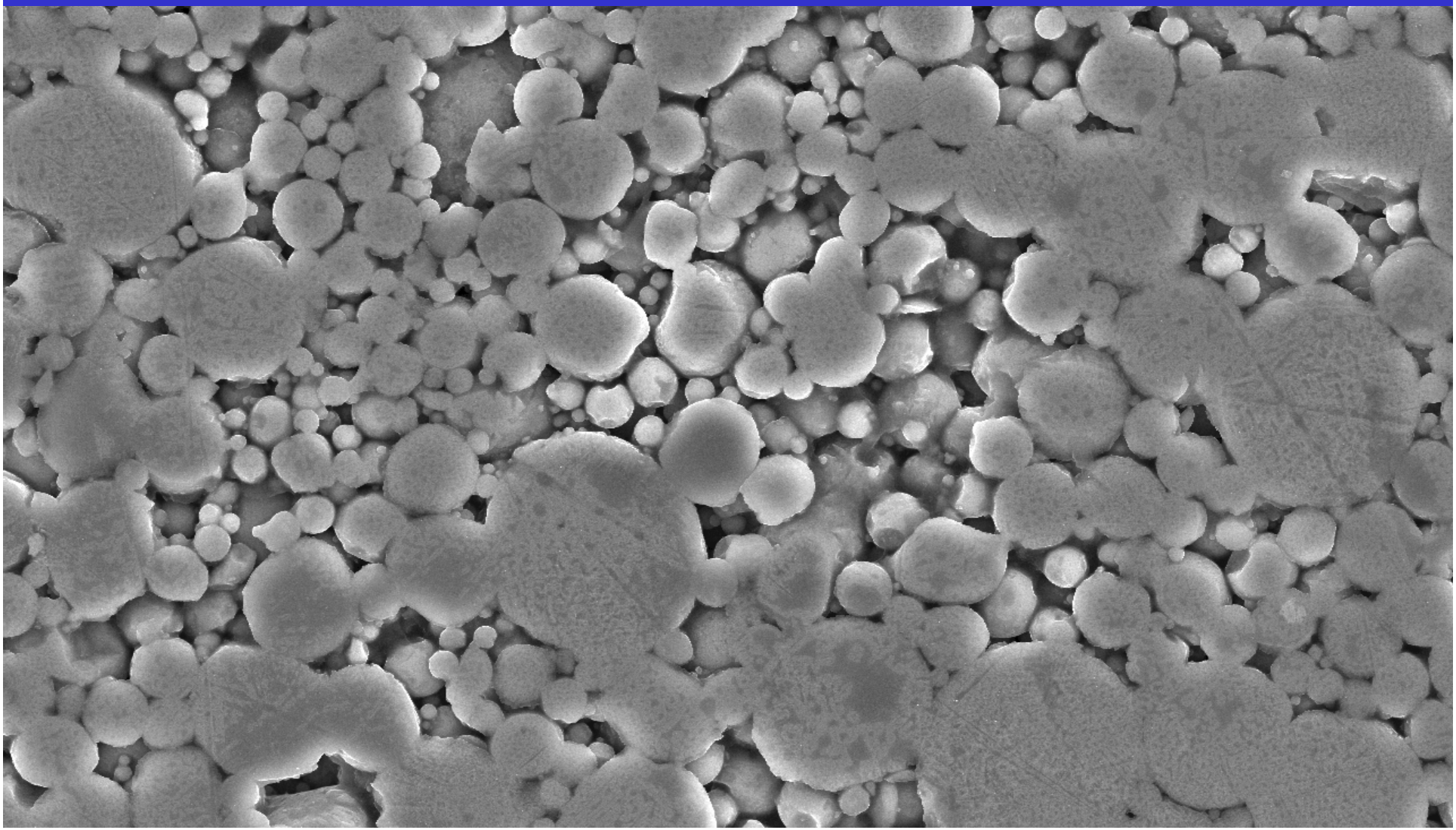
Relative Density

- 550ºF, 80 ksi
- 350ºF, 40 ksi
- 350ºF, 80 ksi
- 350ºF, 100 ksi
- 350ºF, 120 ksi

Amorphous Content

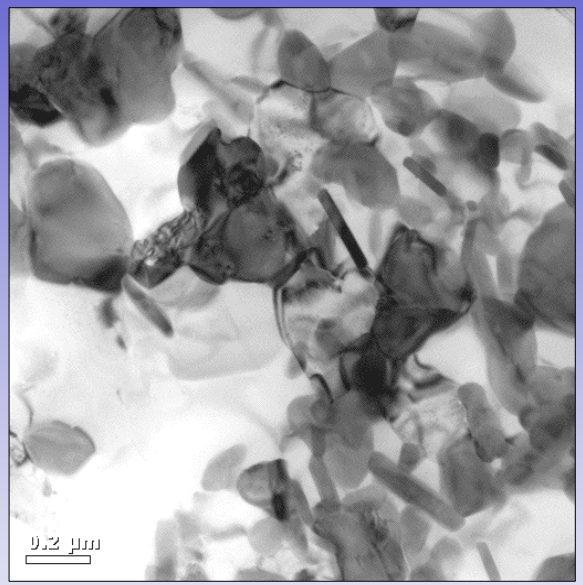
- 550ºF, 80 ksi
- 350ºF, 40 ksi
- 350ºF, 80 ksi
- 350ºF, 100 ksi
- 350ºF, 120 ksi

VHP Billet Densification

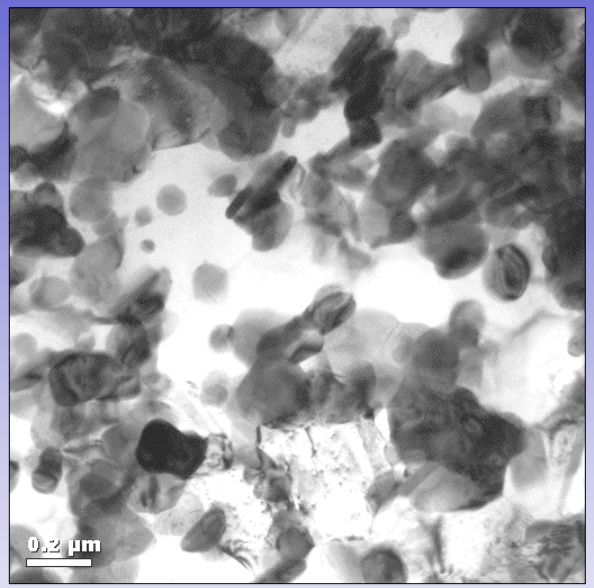


Extrusion Microstructure

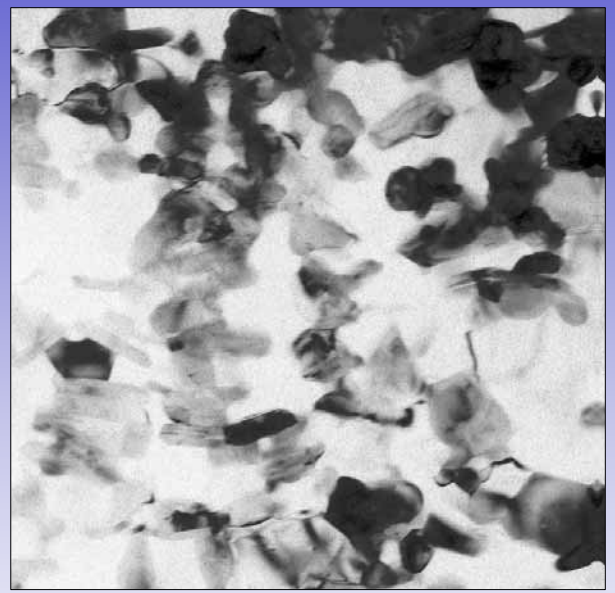
Adiabatic Heating in Extrusion Causes Crystallization



Extrusion Ratio = 5:1



Extrusion Ratio = 10:1

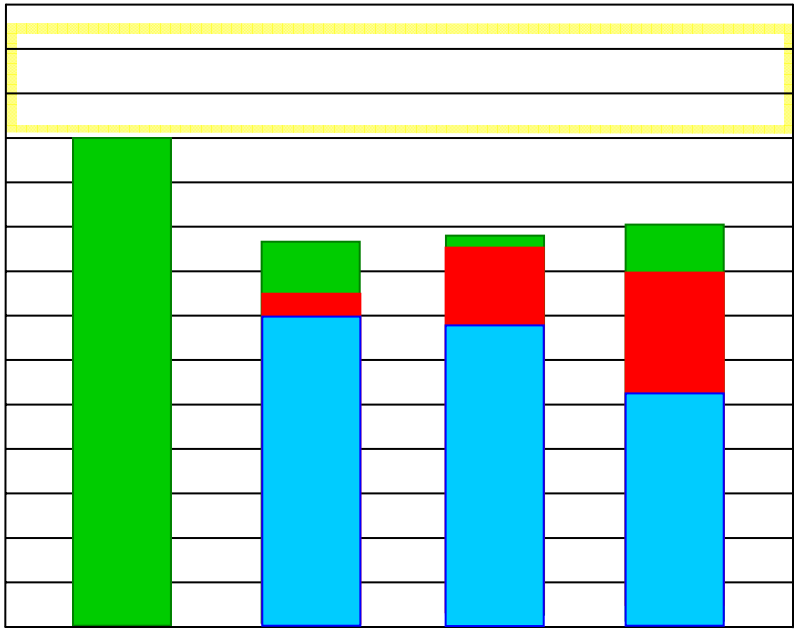


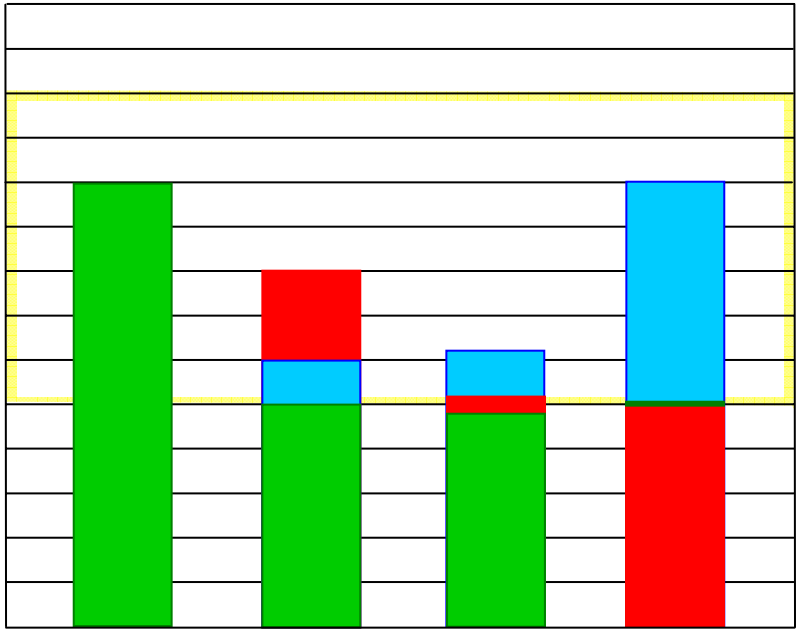
Extrusion Ratio = 20:1

Extrusion Temperature = 350°C

Use of Streamlined Extrusion Dies Combined With Low Extrusion Ratio Does Not Suppress Devitrification

Extrusion Mechanical Properties





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Challenges