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Title: Phase stability and thermophysical properties of Au-Zn-Al

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Phase stability and thermophysical properties of Au-Zn-Al

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Objectives

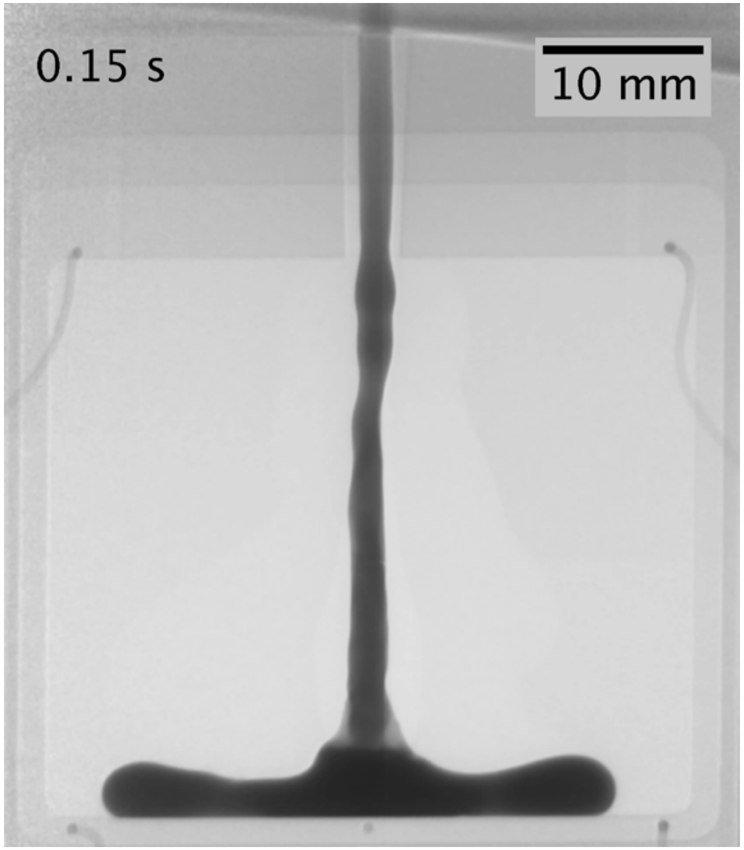
- What are the reasons for looking into Au-Zn-Al?
  - Main alloy of interest: $Au_{65}Zn_{30}Al_5$
- Existing thermodynamic models
- Selection between models
- Application to ternary system
- Vapor pressure assessment

Motivation

- Casting and microstructural prediction
  - Accessible temperature ranges
  - Interesting microstructures

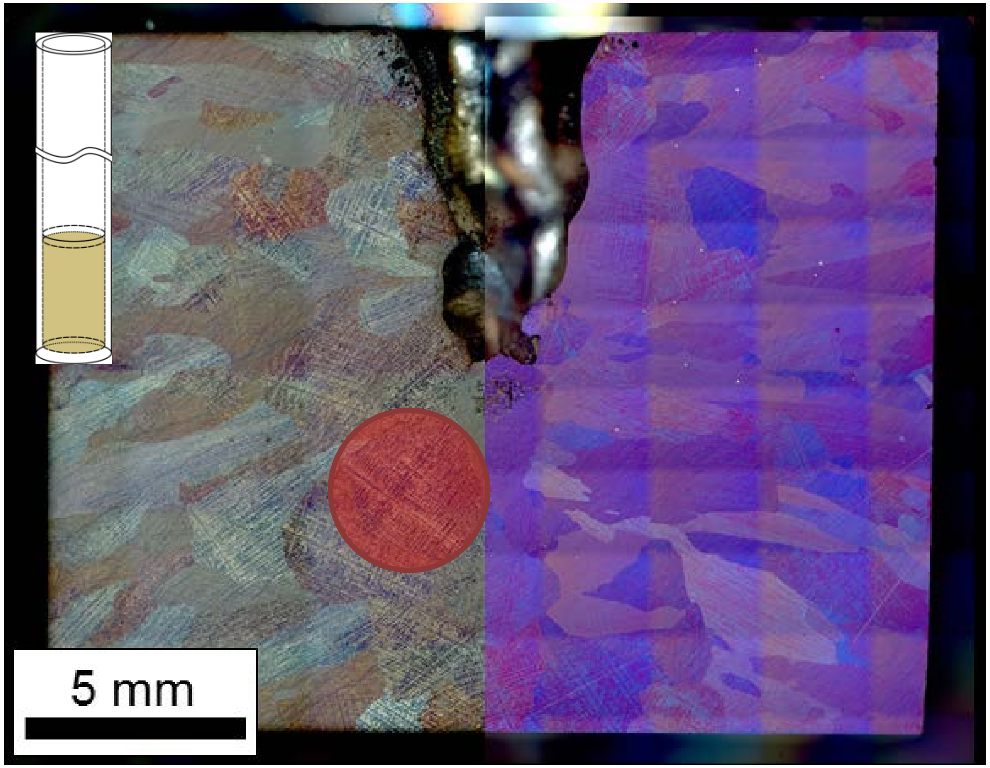
- Practical Concerns
  - Can the castings be reused easily? Chemistry change due to Al oxidation and Zn volatilization

- Amenable to imaging



Alloying

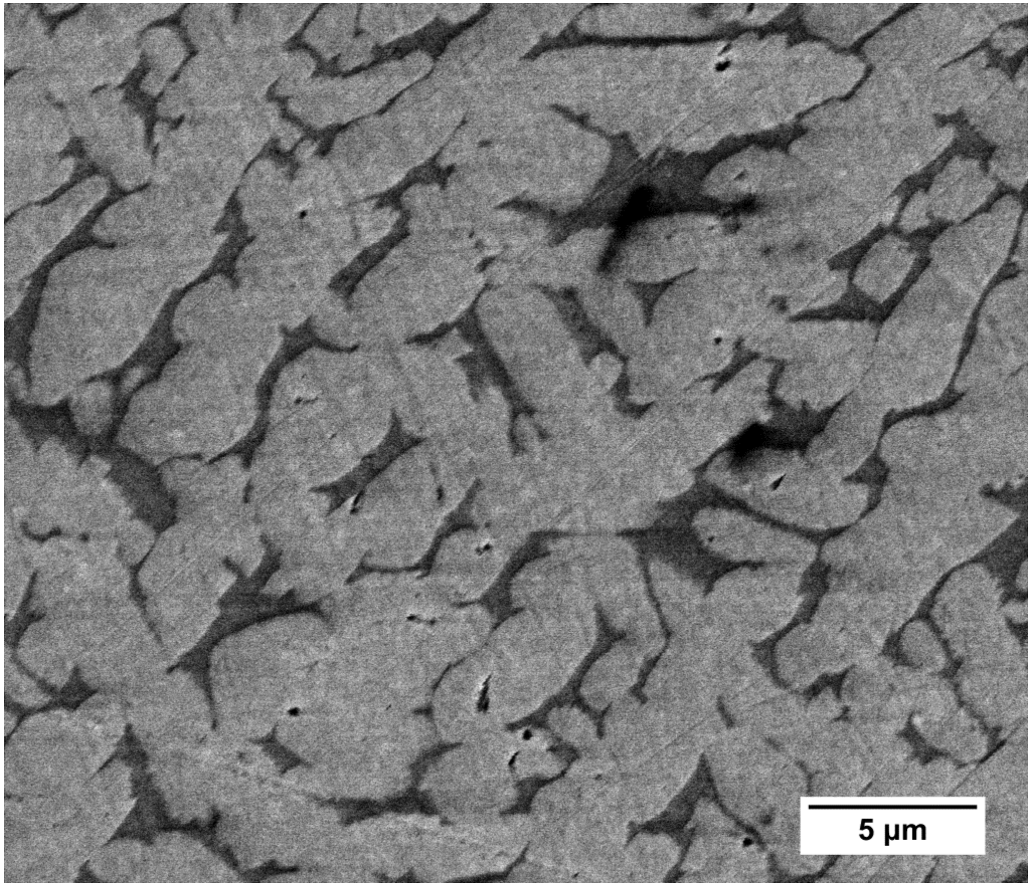
- Sample sizes from 5 – 1000 g
- Quartz encapsulation
  - <10 mTorr
  - 2 x Flushed with Ar
  - Ar backfilled
- 1050°C peak with vigorous shaking. Cooled rapidly by water quench.
- Chemistry:
  - Bulk chemistries from DC Plasma Emission Spectroscopy (ASTM E 1097-12)
  - Locally with EDS



A cross sectional view of a 100g $Au_{65}Zn_{30}Al_5$ (at.%) sample after alloying and quenching. The left-hand side is standard light optical and the right-hand side was captured using polarized light.

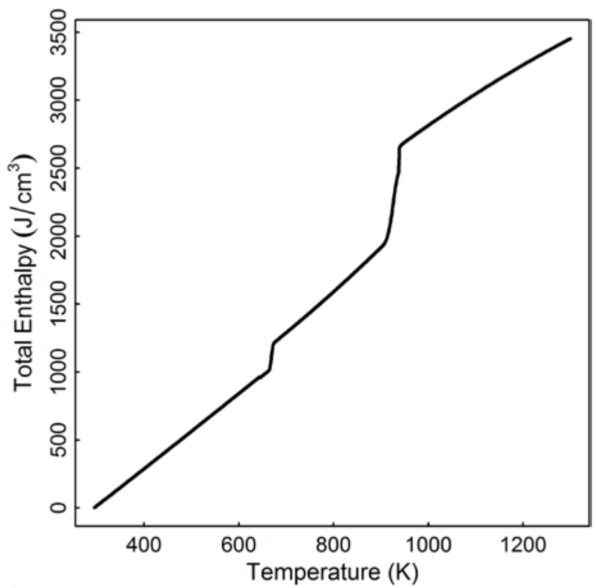
$Au_{65}Zn_{30}Al_5$

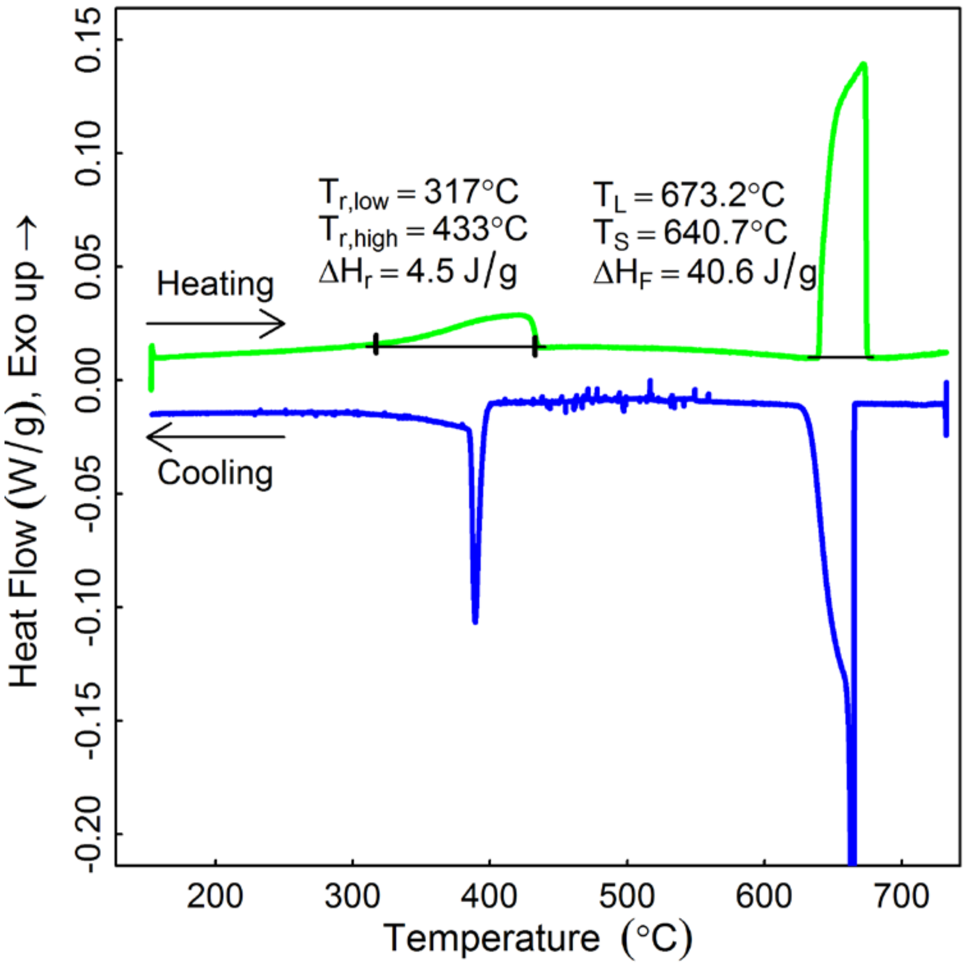
- Mixed microstructure α(light phase) and β(dark phase)
- Primary phase tie line composition at T_L: $Au_{70.8}Zn_{24.8}Al_{4.4}$



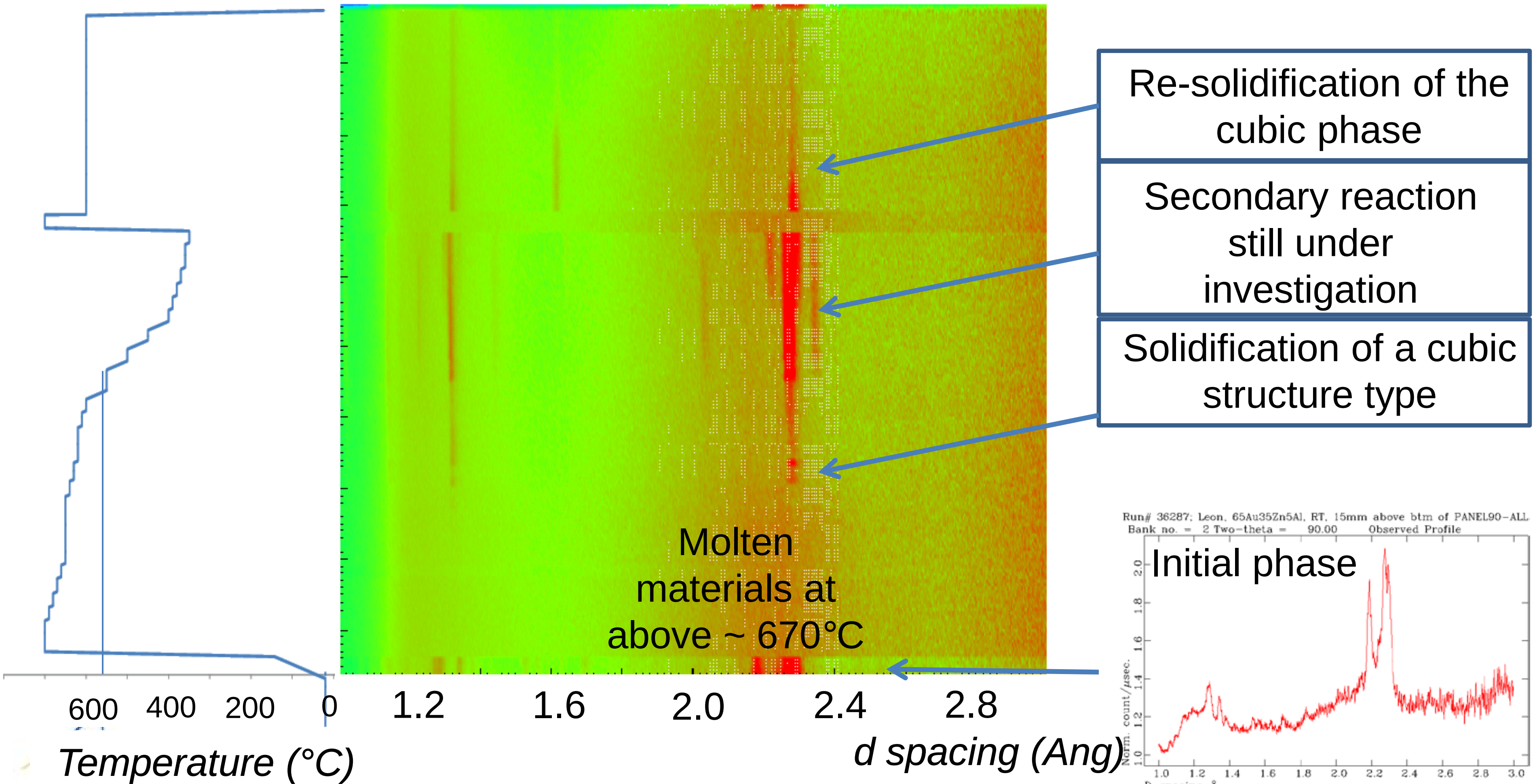
$Au_{65}Zn_{30}Al_5$ Details

- $Au_{65}Zn_{30}Al_5$
  - High density: 15.9 g/cm^3
  - T_L=673°C ; T_S = 640°C
  - Solid state reaction, 380°C
  - α_L=1.885×10^{-5} K^{-1}

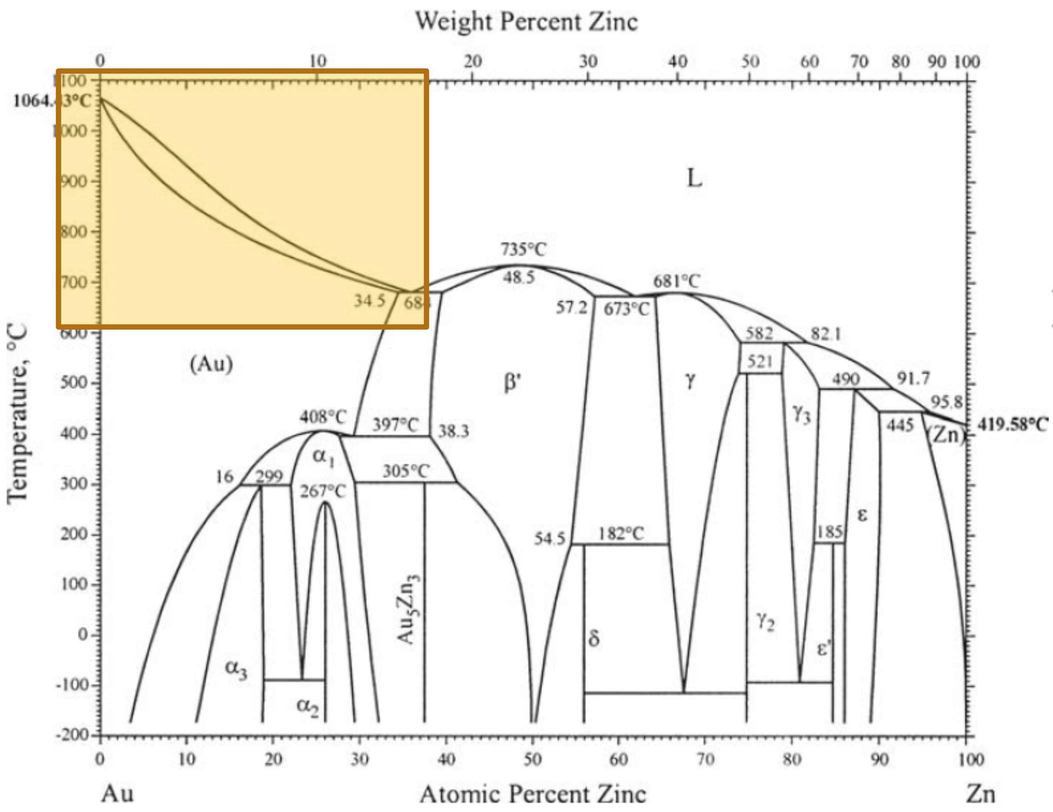




In-Situ Neutron Diffraction study of $Au_{65}Zn_{30}Al_5$



Au-Zn



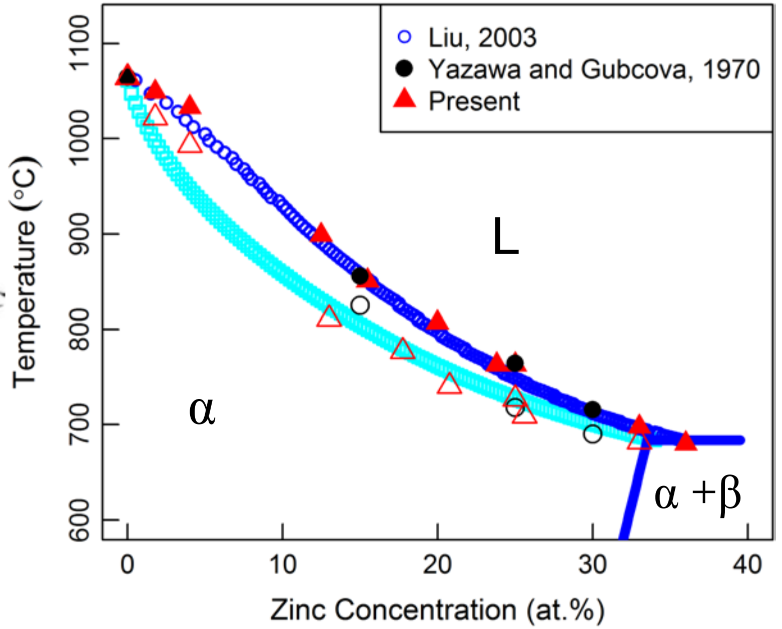
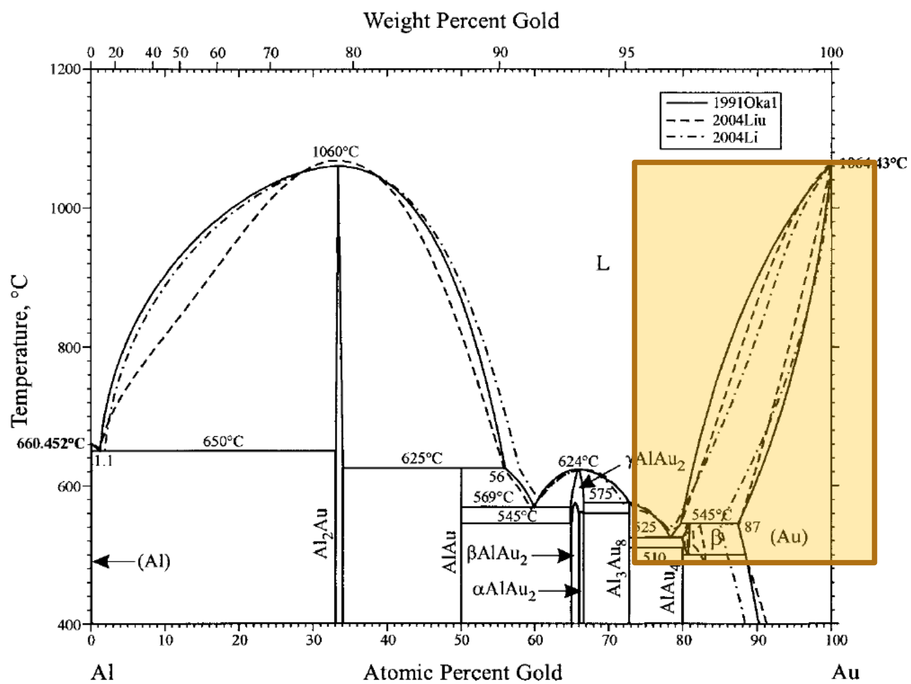


Figure on LHS and interaction parameters for RHS curves from [1].
Pure metal data from [2]
Additional Experimental data from [3]

Au-Al



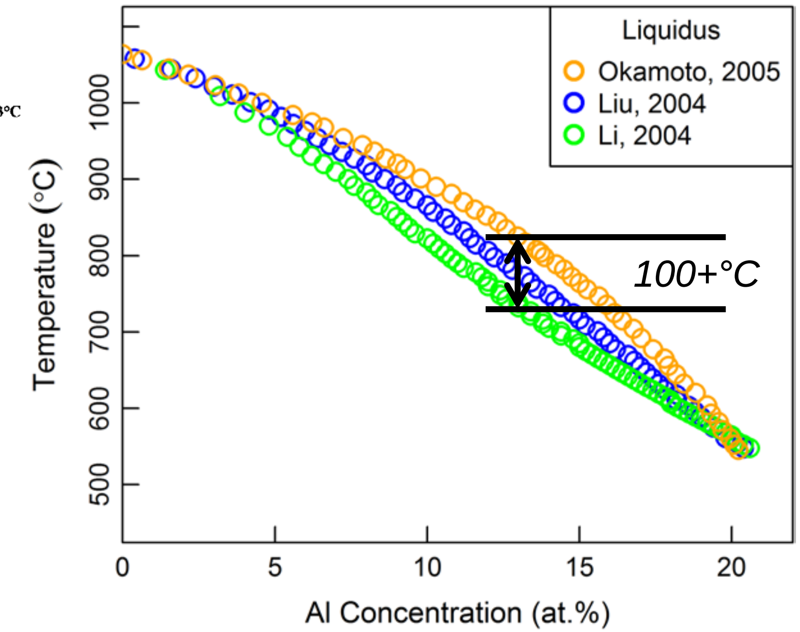
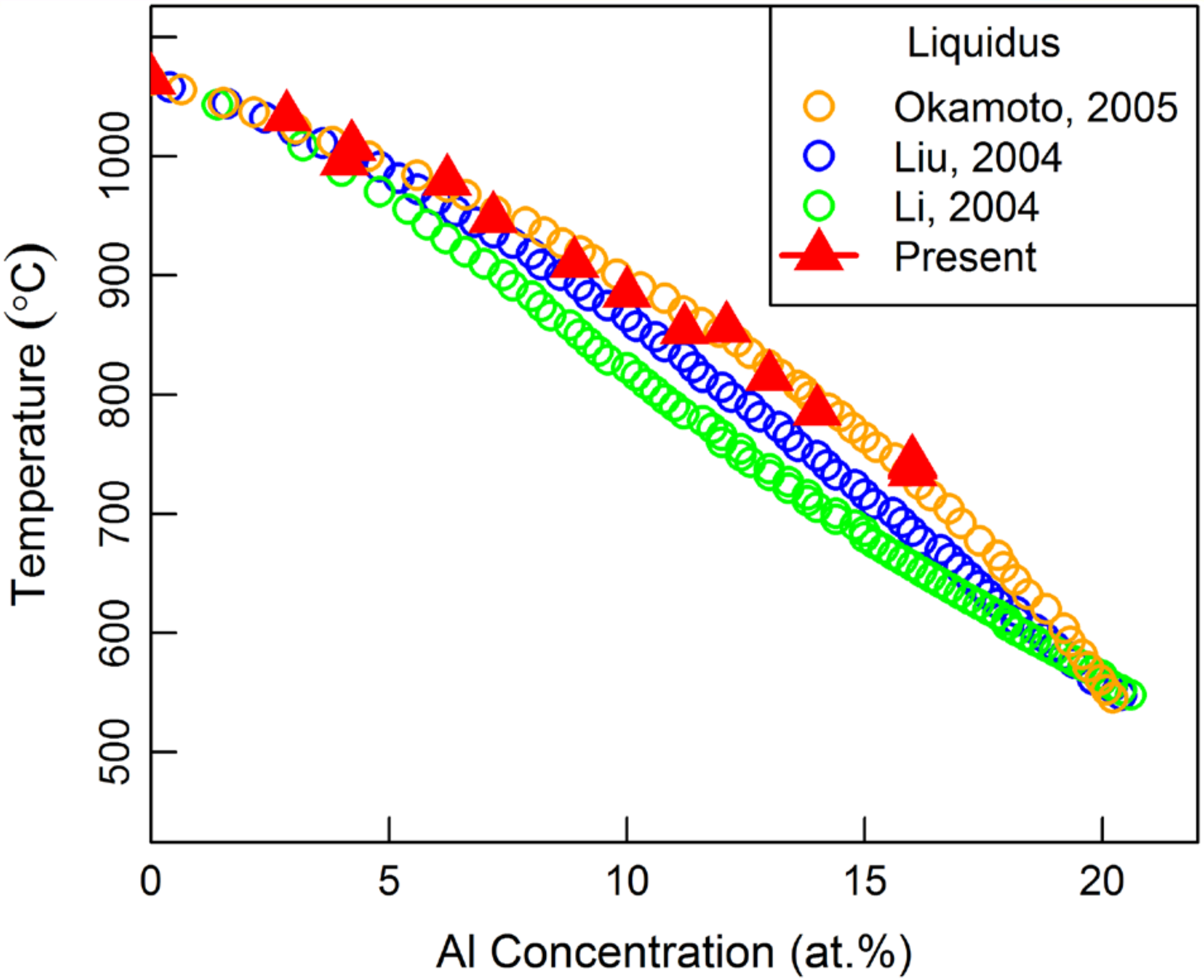
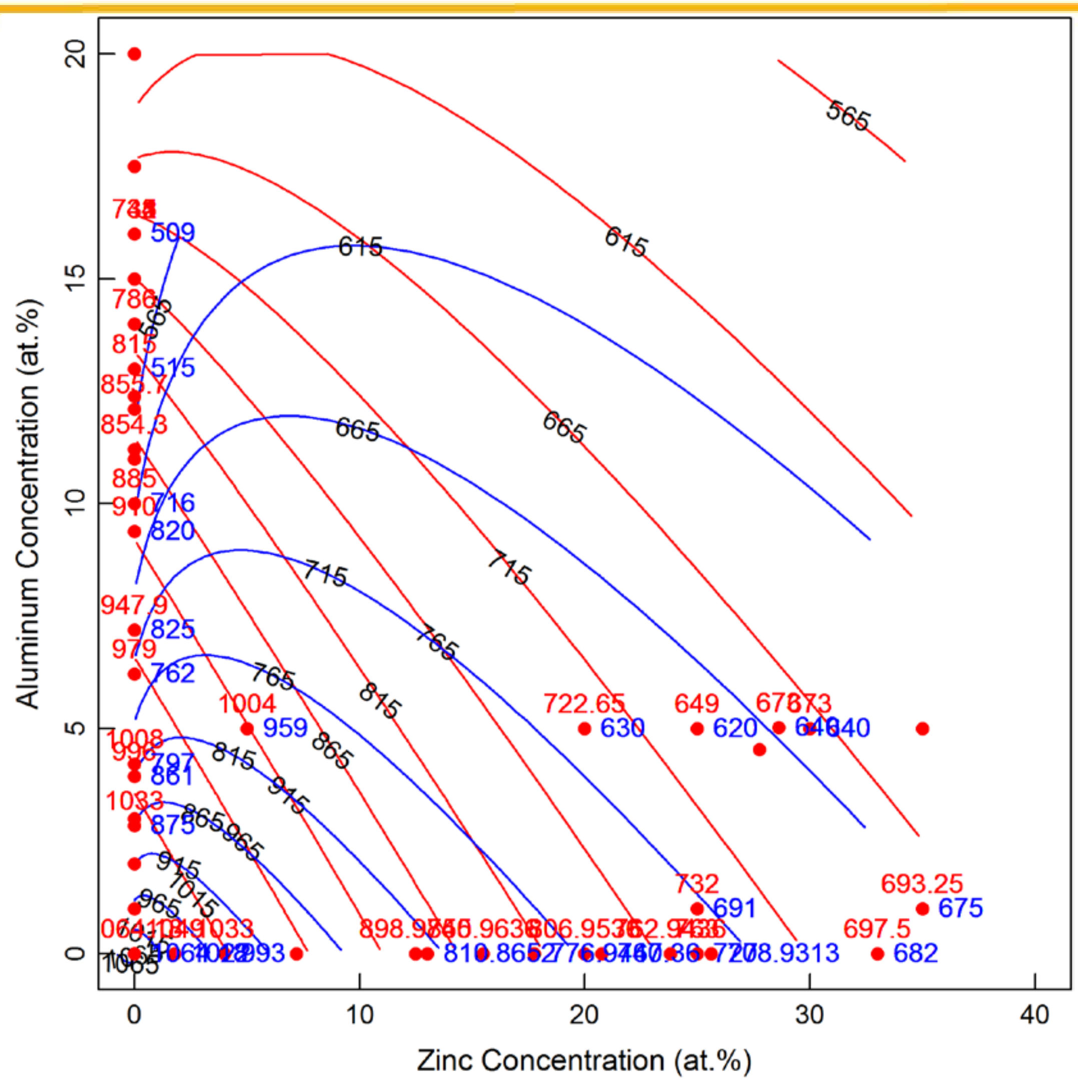


Figure from [4], models from [5], [6], [7].

Model selection



A lot to look at… it won’t be long



A small example

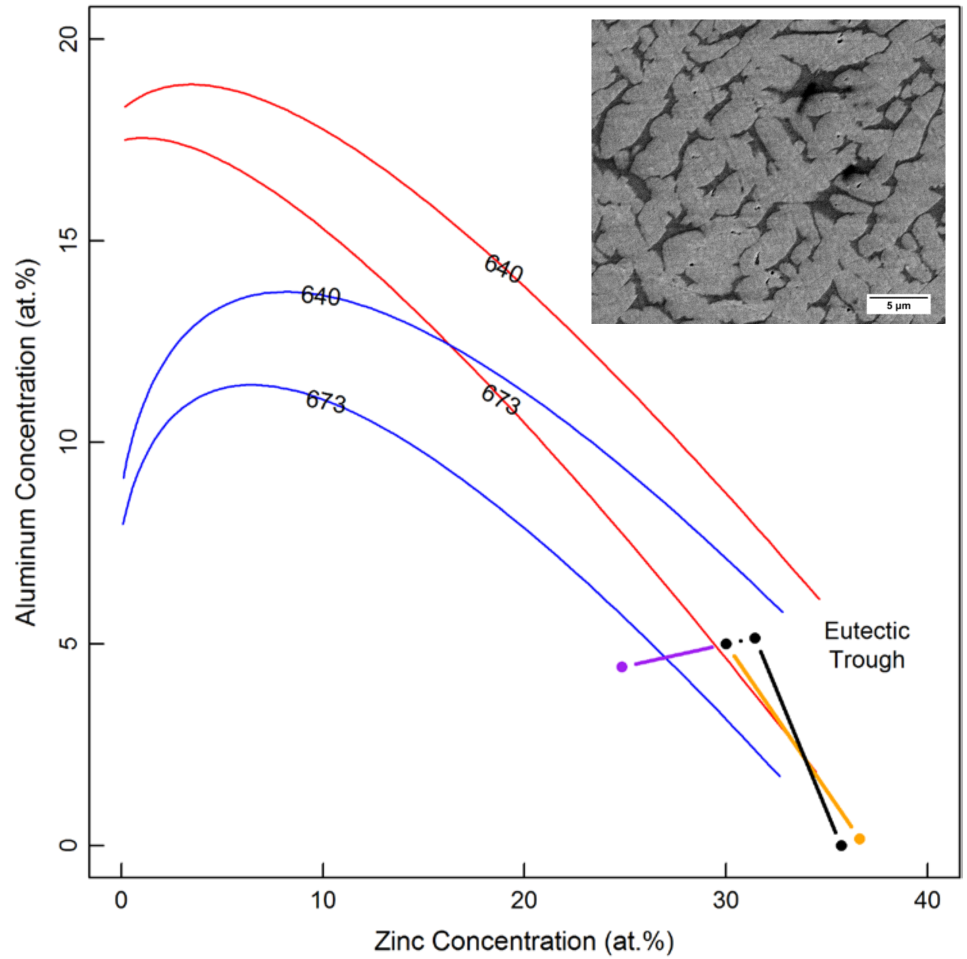
$C_0 = Au_{65}Zn_{30}Al_5$ (at.%)

$V_f(fcc) \approx 78\%$

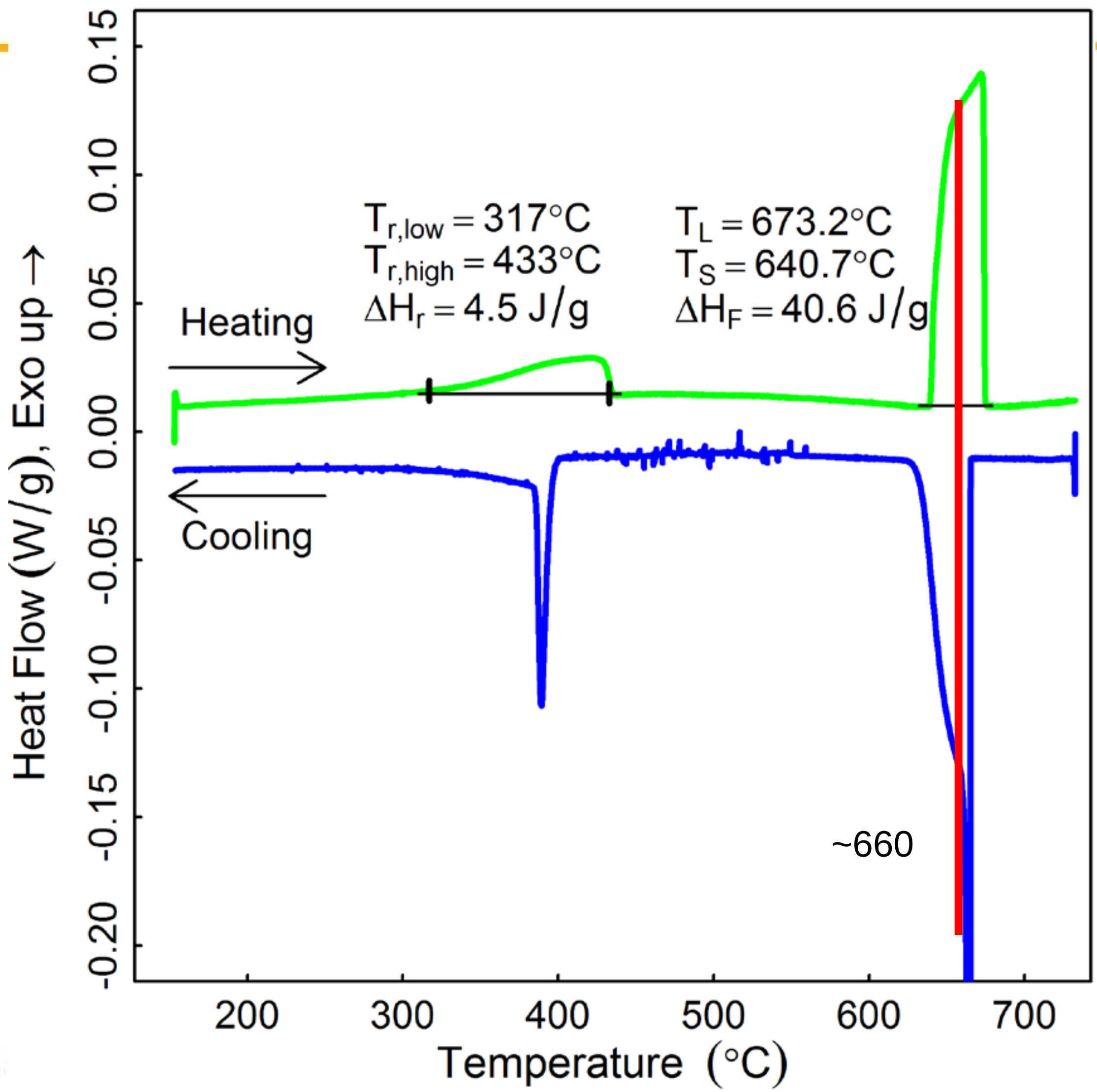
1. An approximate tie line composition can be obtained through EDS.

2. The liquid composition at the eutectic trough can be estimated

Temperature?

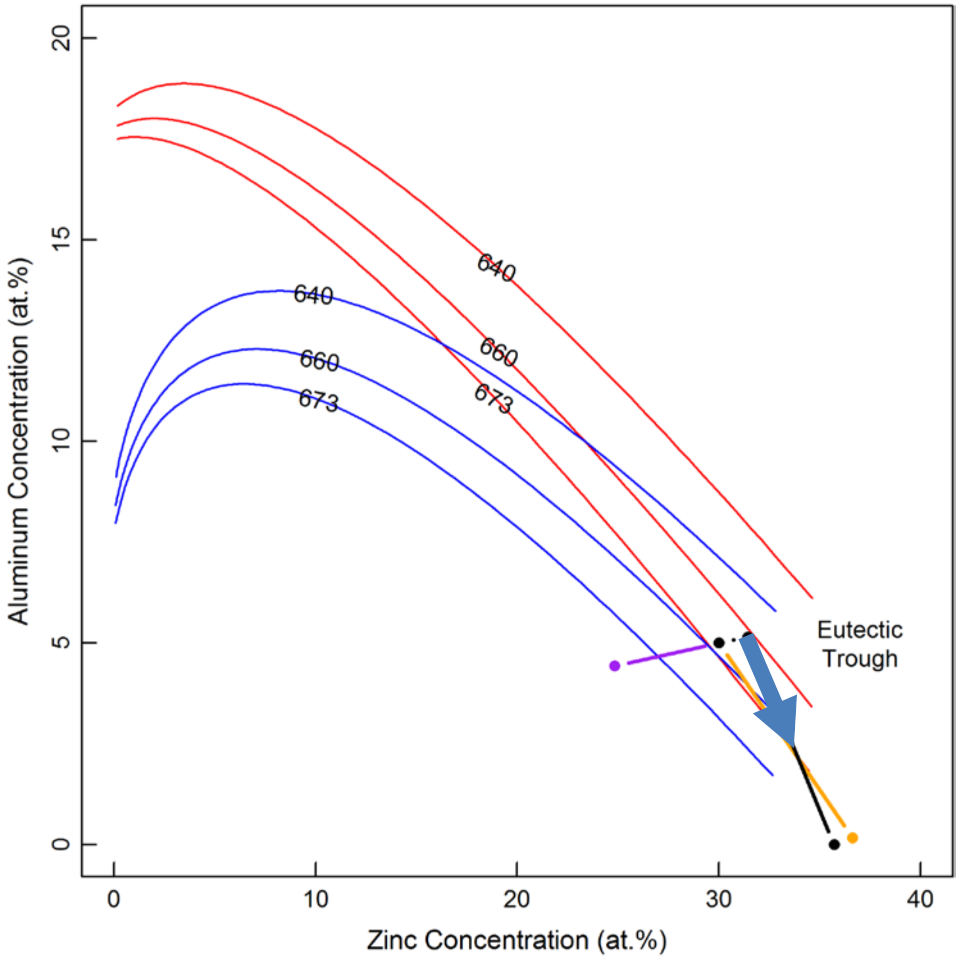


Ternary Details

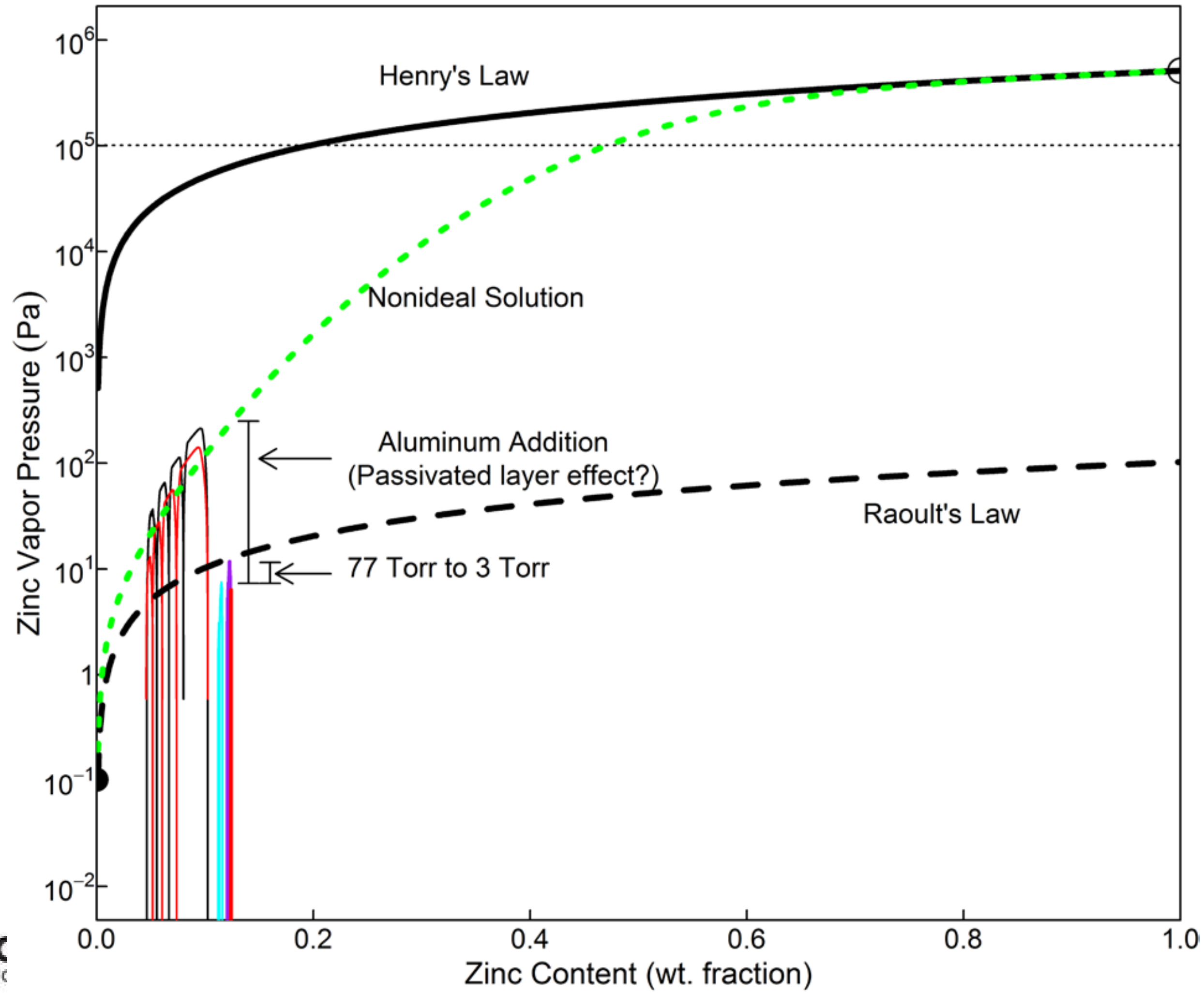


How'd we do?

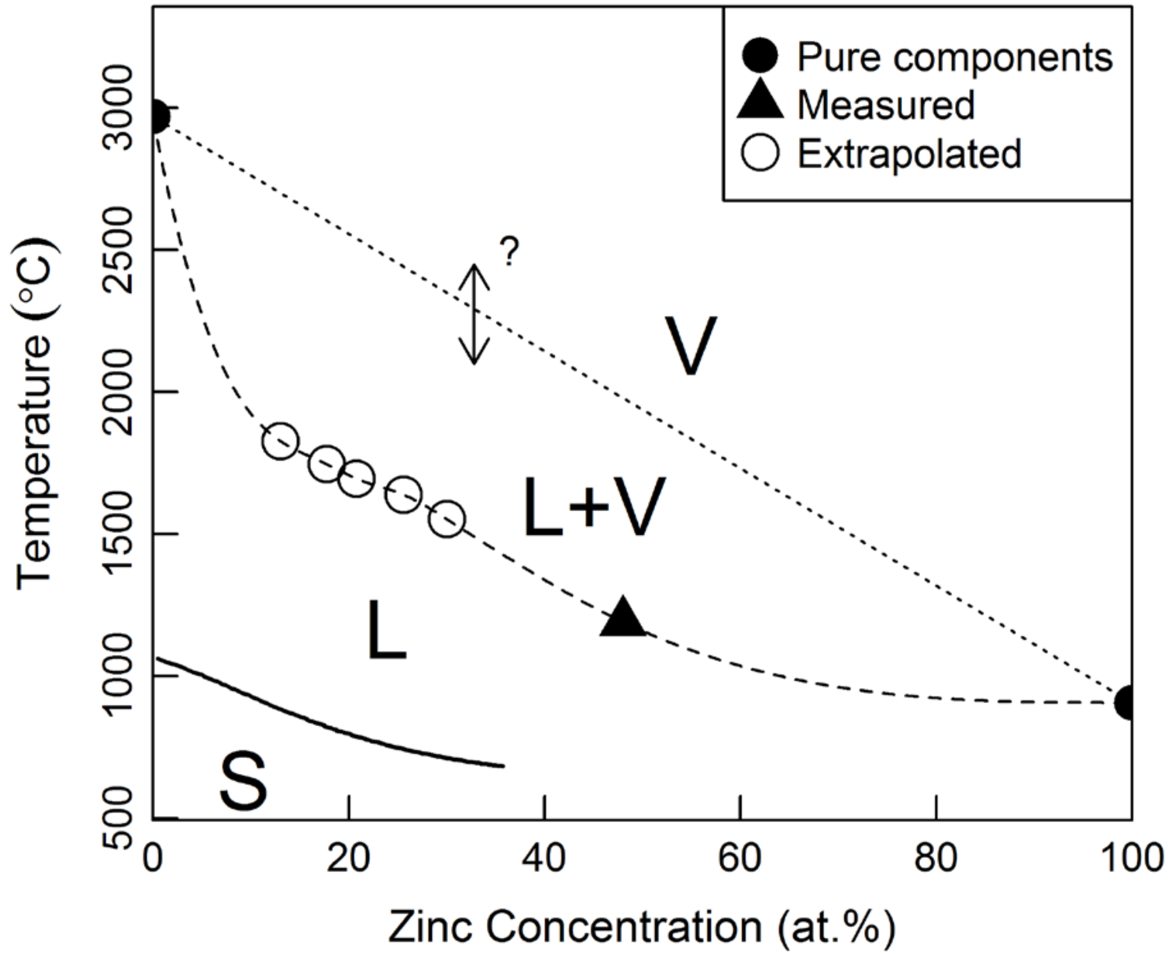
- The liquidus estimation (with dilute Al) is reasonable.
- Prediction of solidus temperatures will require a formal model.



Mass loss and vapor pressure



Some gas phase information



Conclusions and future work

- Binary models have been examined on the Au-rich side of the Au-Al and Au-Zn phase diagrams
  - Current Au-Zn model is appropriate
  - Interaction parameters from Murray et. al. and formal assessment of Okamoto fits the Au-Al data best
- Zinc vapor pressure has been assessed in order to determine the ability to reuse these alloys after casting.
- A preliminary ternary model gives reasonable agreement with the data, but further investigation is necessary
- In-situ diffraction studies are as of yet inconclusive in the ternary region, but work is ongoing.
- Microstructure predictions

References

- [1] H.S. Liu, K Ishida, Z.P. Jin, Y. Du, “Thermodynamic assessment of the Au-Zn binary system”, Intermetallics 11 (2003), 987-994.
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- [7] M. Li, C. Li, F. Wang, D. Luo, W. Zhang, “Thermodynamic assessment of the Al-Au system” Journal of Alloys and Compounds 385 (2004) 199-206.