Institute of Materials Physics in Space

Dichte und Molvolumen flüssiger Al-Ti Legierungen

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Al-Ti based alloys

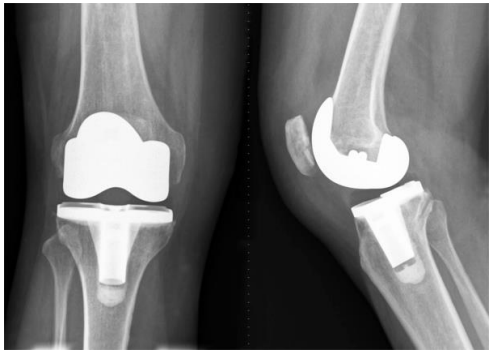
Properties:

+ High temperature resistance
+ Light weight
+ Biocompatibility
+ Low ductility and toughness

Applications in various sectors:

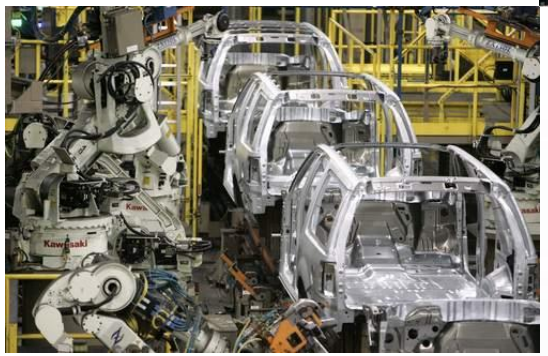
www.deusm.com

Aeronautic



www.medgadget.com

Medical Engineering



www.marinatextil.net

Automotive

Industrially used Al-Ti alloys

- For industrial processing thermophysical property data, e.g. viscosity and surface tension is needed
- Crucial for numeric simulations and casting processes: Density
- Density and mixing behavior of alloys often assumed to be ideal and calculated from data for the pure elements

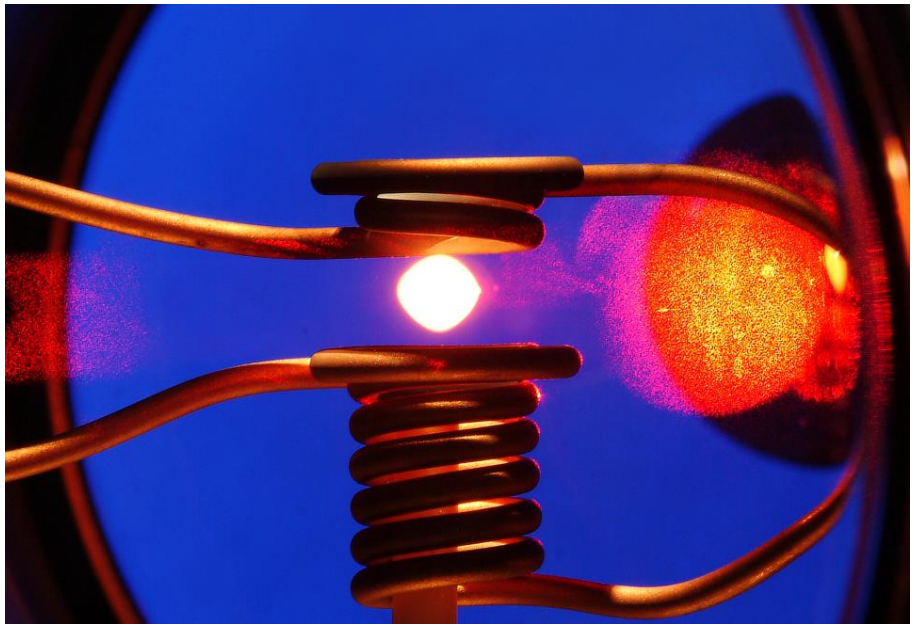
Al-Ti ideal mixing behavior = Al-Ti real mixing behavior ?!

Grytsiv, Rogl, Schmidt, Giester, J. Phase Equ. (2003)

Challenges

- High chemical reactivity of Ti and Al-based melts

→ Solution: Containerless processing using levitation techniques



Access to:

- **Highly reactive materials**
- **High temperatures**
- **Undercooling**

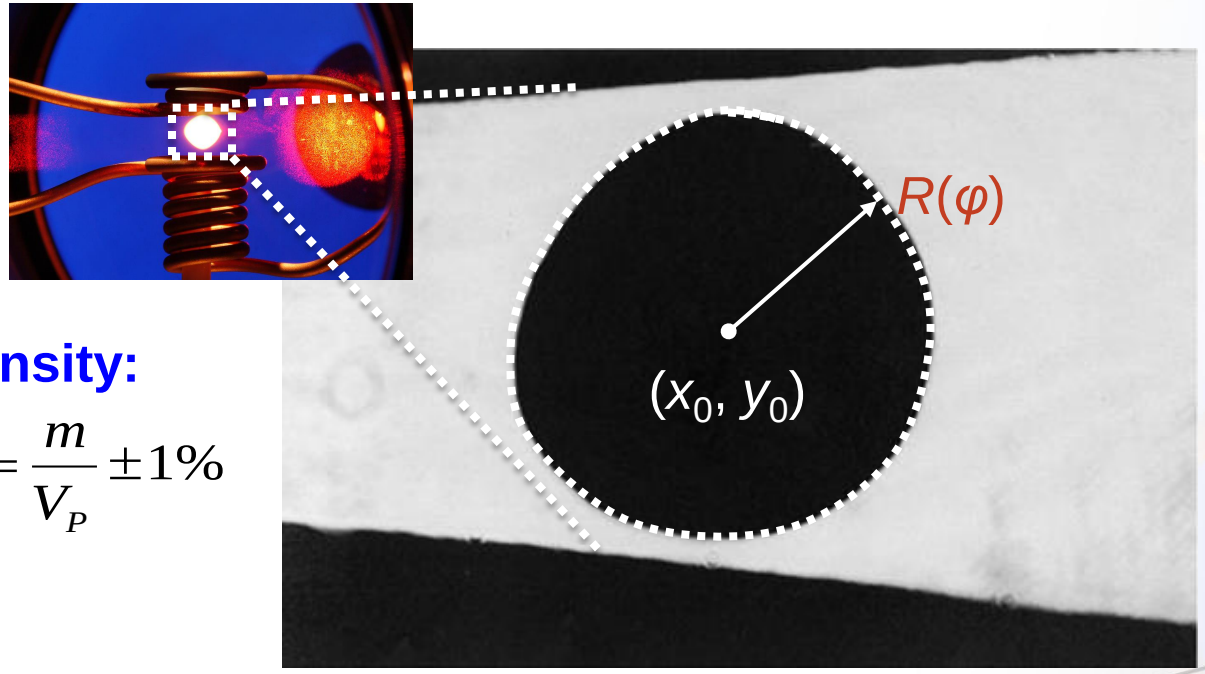
Density measurement

Edge fit using Legendre polynomial:

$$\langle R(\varphi)\rangle = \sum_{i=0}^{6} a_i P_i(\cos(\varphi))$$

Volume calculation:

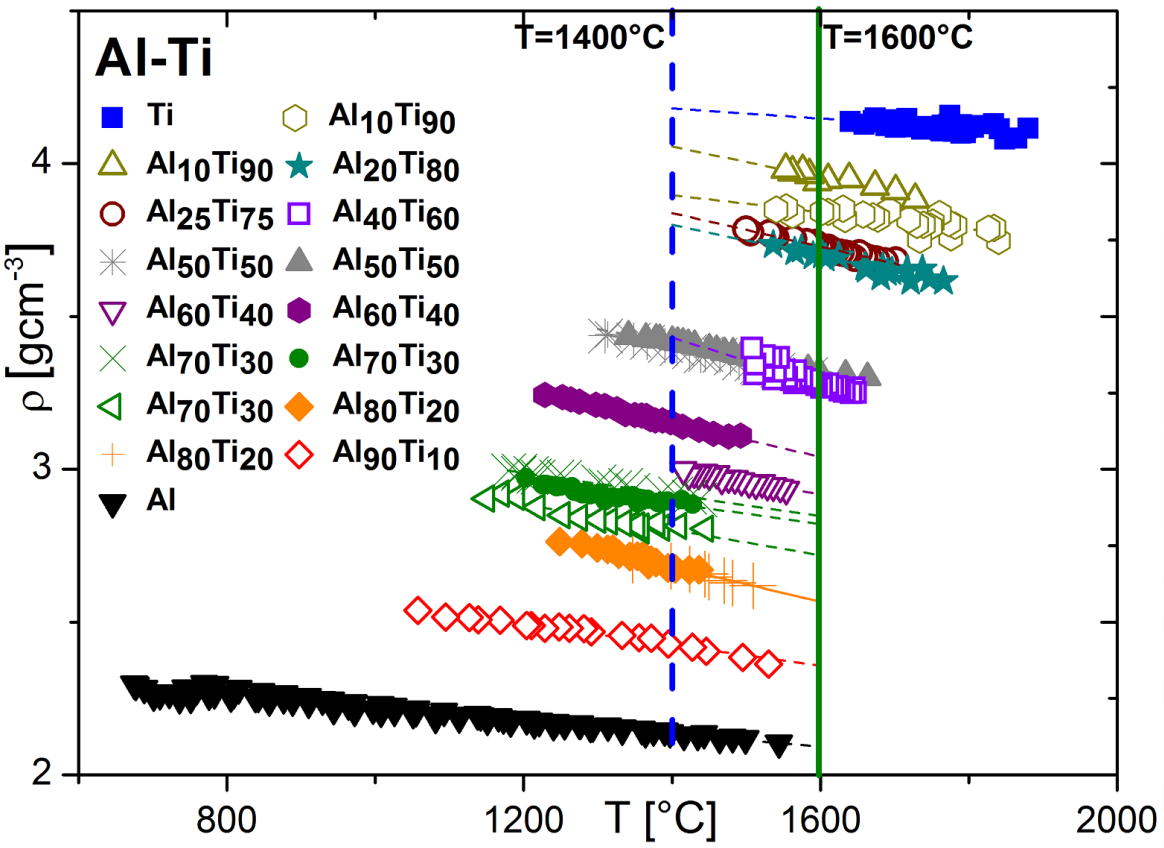
$$V_P = \frac{2}{3}\pi \int_0^{\pi} \langle R(\varphi)\rangle^3 \sin(\varphi) d\varphi$$



Density:

$$\rho = \frac{m}{V_P} \pm 1\%$$

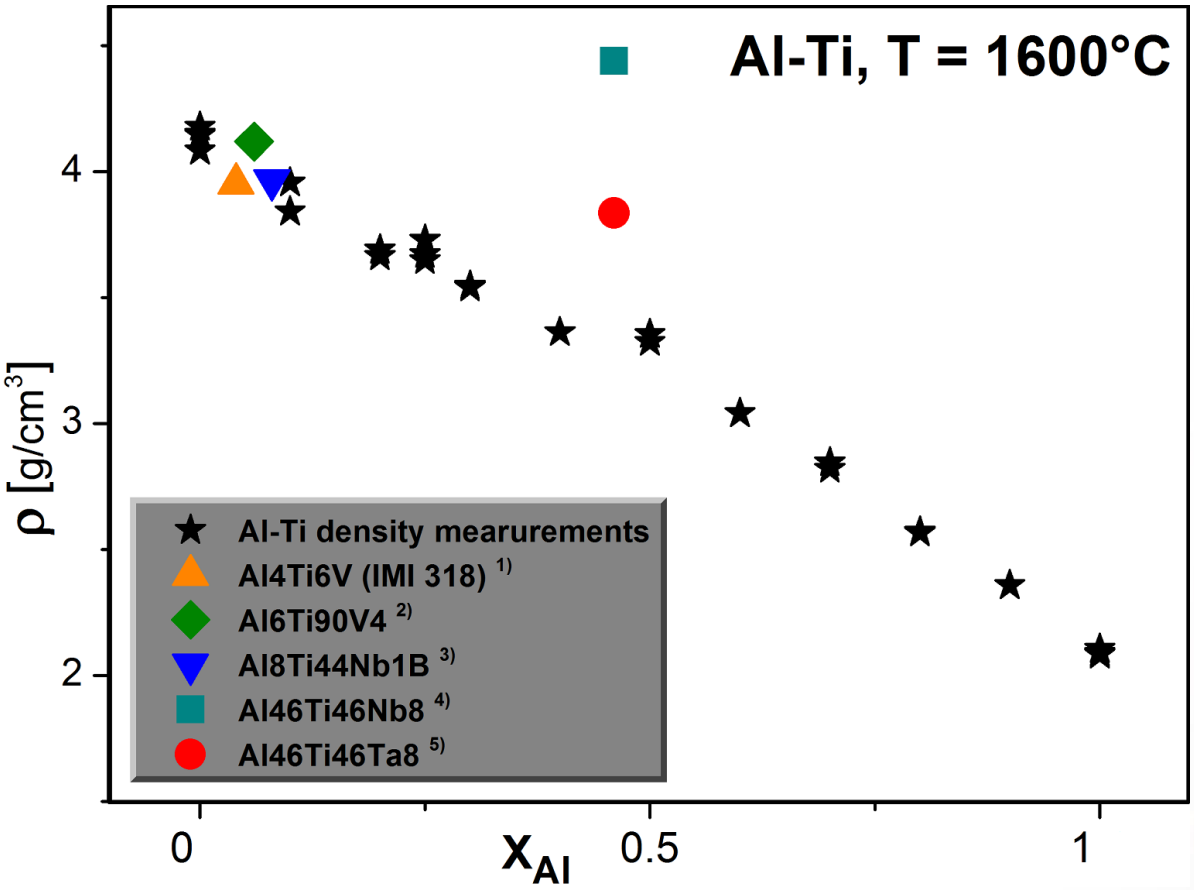
Al-Ti, Density as a function of temperature



- **Density depends linearly on temperature:**

$$\rho(\mathrm{T}) = \rho_L + \rho_T (T - T_L)$$

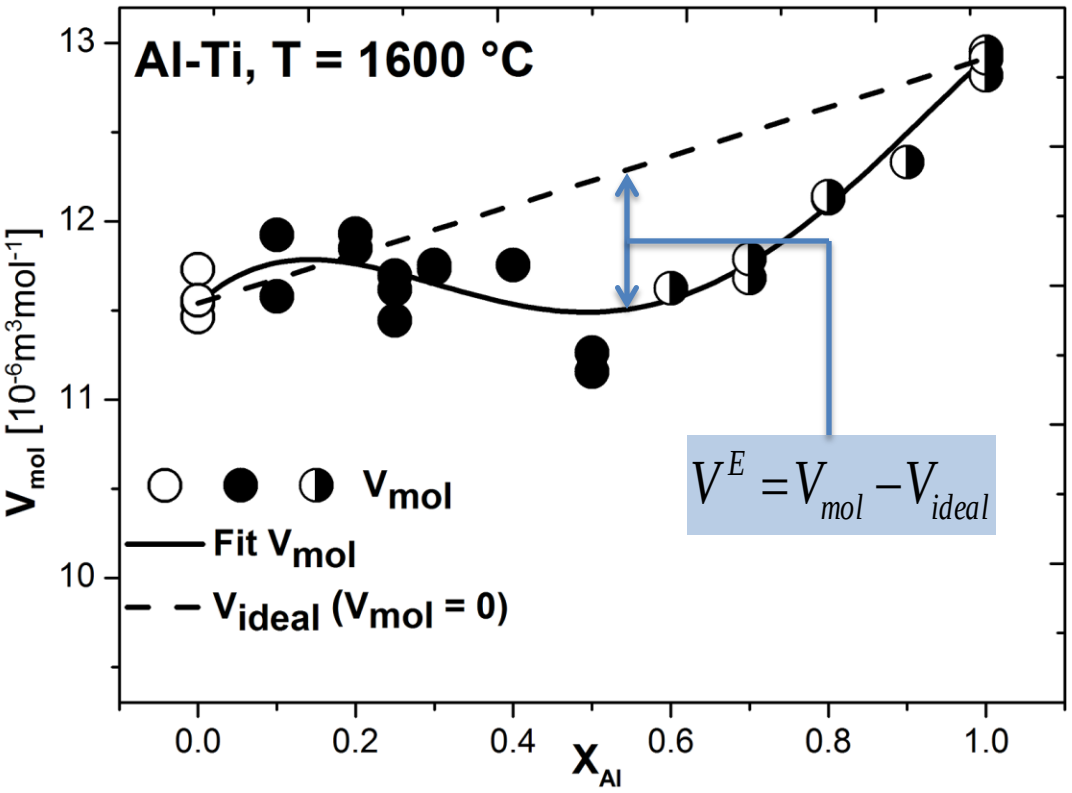
Al-Ti, density as a function of composition



- **Measured densities for Al-Ti vary between 2,09 g/cm³ for pure Al and 4,15 g/cm³ for pure Ti**

1) Mills (2002), 2), 4), 5) Holland-Moritz, Egry et al. (2009), 3) Harding, Brillo, Pottlacher et al. (2003)

Al-Ti, ideal and real molar volume



Ideal molar volume:

$$V_{ideal} = \frac{X_{Al} M_{Al}}{\rho_{Al}} + \frac{(1 - X_{Al}) M_{Ti}}{\rho_{Ti}}$$

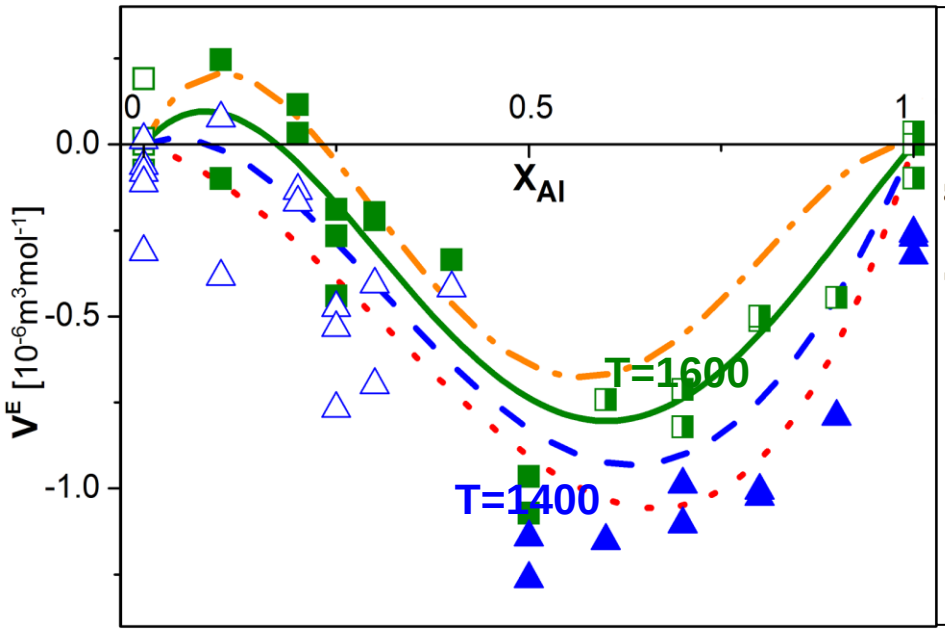
Real molar volume:

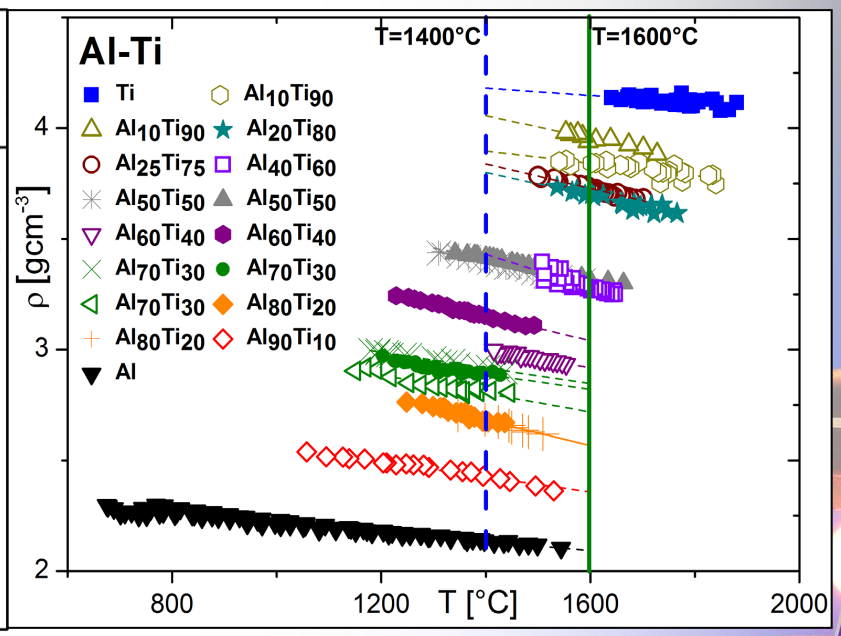
$$V_{mol} = \frac{X_{Al} M_{Al} + (1 - X_{Al}) M_{Ti}}{\rho_{Al_X Ti_{1-X}}}$$

→ **Negative excess molar volume**

→ **Maximum for Al ≈ 60 Mol%**

Al-Ti, excess molar volume





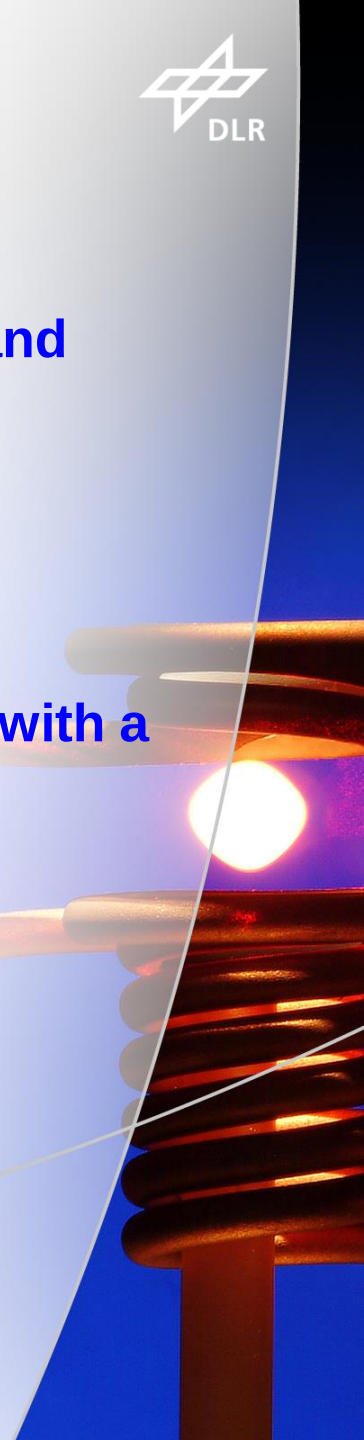
- **Negative excess molar volume decreases with increasing temperature**
- **V^E fit Redlich-Kister polynomial third order:**

$$V^E(X_{Al}) = X_{Al}(1-X_{Al})\sum_{i=0}^{2} V_i^E (2X_{Al}-1)^i$$

Summary

- **Density has been measured over a broad temperature and composition range**
- **Molar volume and excess molar volume have been evaluated**
- **Al-Ti alloys show large negative excess molar volumes with a maximum value for Al ≈ 60 Mol%**

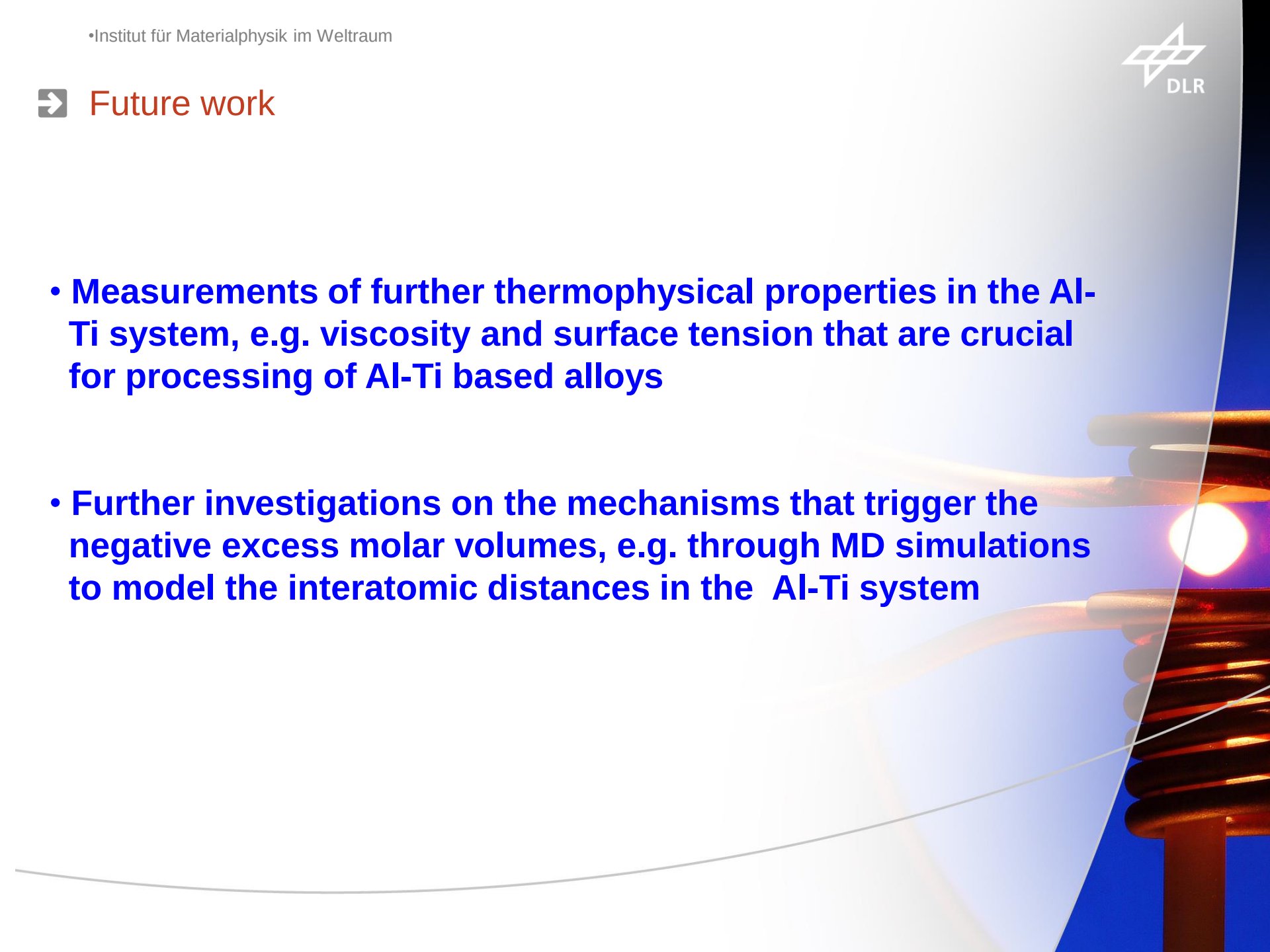
→ Mixing behavior of Al-Ti nonideal!!



Future work

- **Measurements of further thermophysical properties in the Al-Ti system, e.g. viscosity and surface tension that are crucial for processing of Al-Ti based alloys**

- **Further investigations on the mechanisms that trigger the negative excess molar volumes, e.g. through MD simulations to model the interatomic distances in the Al-Ti system**



Thank you for your attention!!!