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Thermodynamic properties of molten Eu-Ge and lanthanide-Ge alloys

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INTRODUCTION

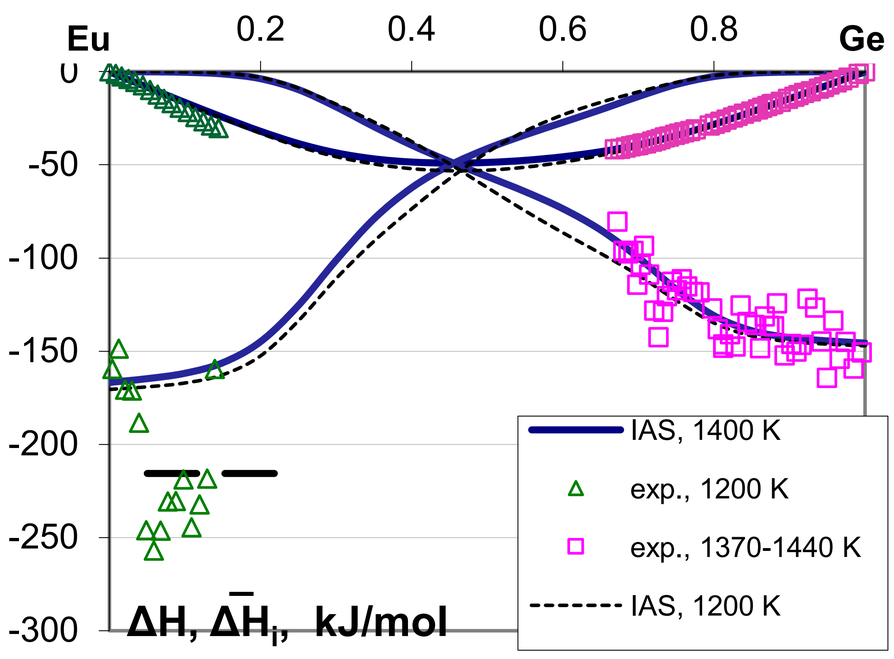
Systematic thermodynamic study of liquid alloys containing lanthanides (La-Lu), p-elements (Al, Si, Ge, Sn, Sb, Pb, Bi) and d-elements (Fe, Co, Ni, Cu, Ag) has been underway at Frantsevich IPMS and Kyiv National University (Ukraine) since 1990s.

METHODS

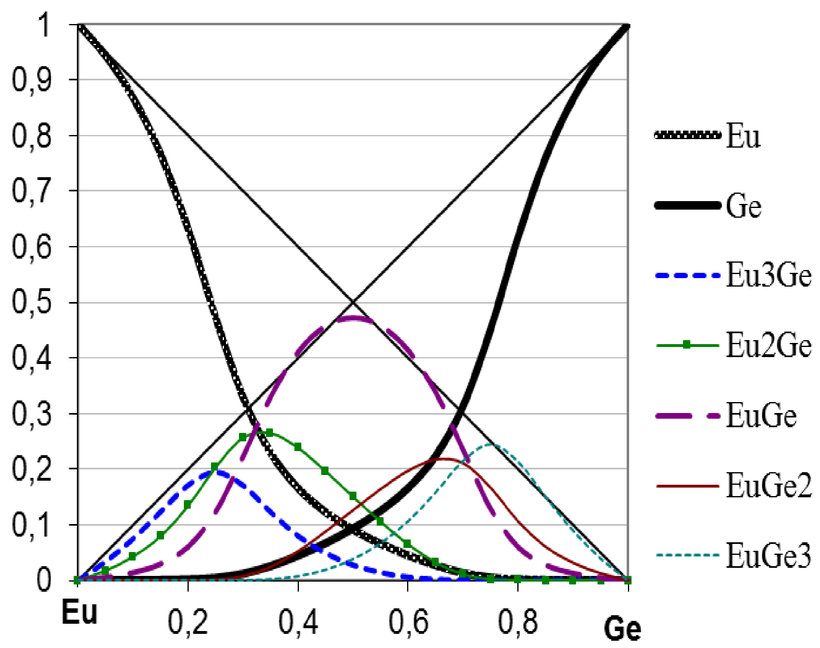
- Enthalpies of mixing of the liquid Eu-Ge alloys have been determined at 1200-1440 K over the whole range of compositions.
- Ideal Associated Solution (IAS) model has been implemented to describe the measured thermodynamic properties of liquid Eu-Ge alloys, coupled with the literature data on liquidus and thermodynamic properties of solid intermetallics. Five associates (Eu3Ge, Eu2Ge, EuGe, EuGe2, and EuGe3) were used.

RESULTS

- Minimum enthalpy of mixing was found to be 49.1±4.4 kJ/mol at 1400 K and x(Ge) = 0.45, which agrees with the behaviour of the same alloys in solid state.
- Large negative deviations from ideality are predicted for the activities of components.



Integral and partial enthalpies of mixing of melts of the Eu–Ge system

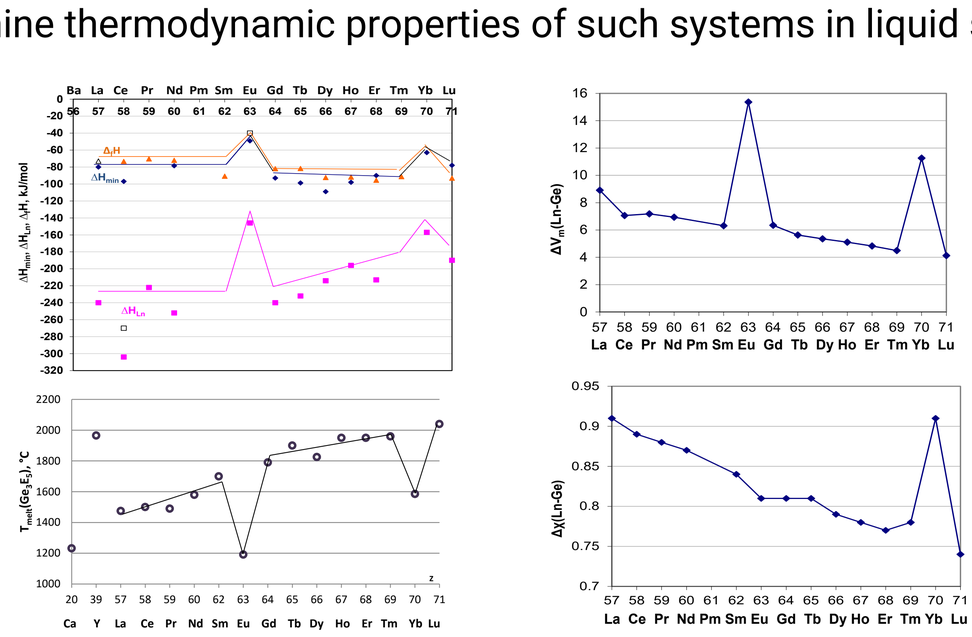


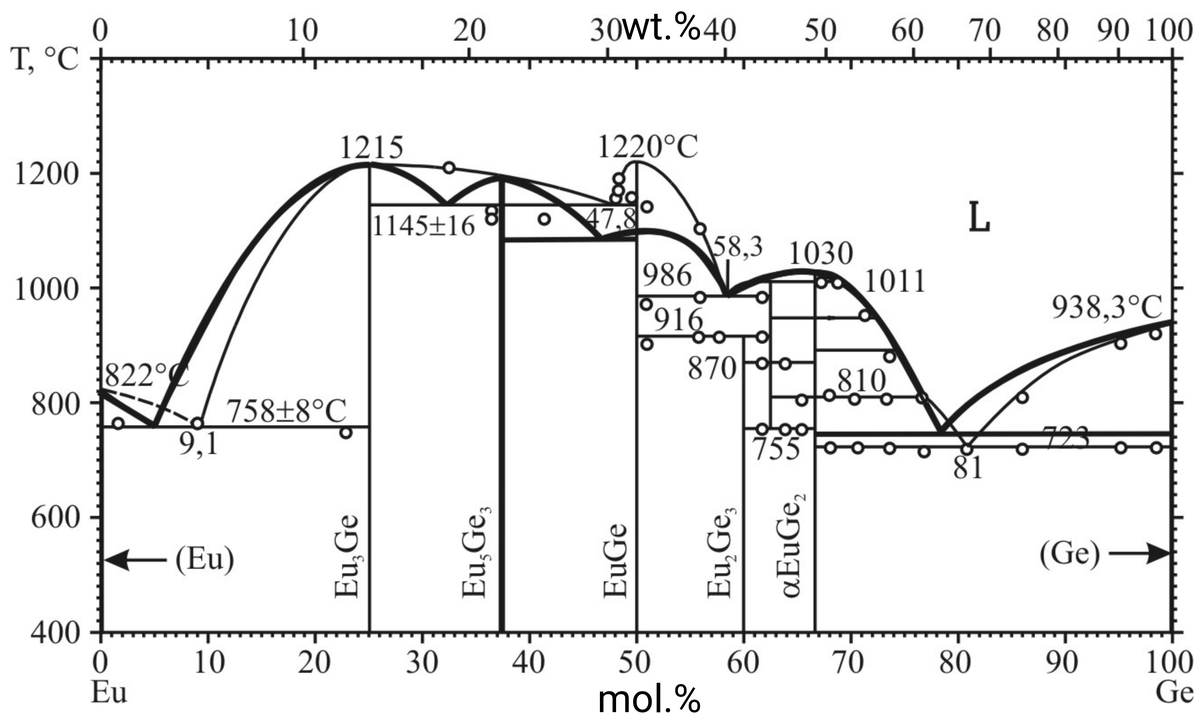
Activities of components and mole fractions of associates in melts at 1400 K according to the IAS model

Enthalpies and entropies of formation of intermetallics (sol) and hypothetical associates (liq)

DISCUSSION

The Eu-Ge system has been reviewed as a member of the Ln-Ge (Ln=lanthanide) series to identify what are the key factors that determine thermodynamic properties of such systems in liquid state.





CONCLUSION

- The overall thermodynamic model was used to calculate temperature and composition dependence of liquid alloys (IAS model) and solid phases (stoichiometric compounds), and therefore the phase diagram of the system.
- There are discrepancies between the calculated liquidus from literature data. Our calculation supports stability of the Eu_5Ge_3 compound, which was only reported in some of the literature sources.
- The currently available Eu-Ge phase diagram is therefore incomplete and requires further investigation.