# Thermophysical Properties of Near-Eutectic Gallium-Indium-Tin Alloy

Matthias H. Buschmann[1, S, C], Maria José V. Lourenço[2], Fernando J.V. Santos[2], Valentim M.B. Nunes[3], Miguel Alves[2], João M. Serra[2], Carlos Nieto de Castro[2], Ronny Künanz[4], Christian Hanzelmann[4] and Steffen Feja[4]

[1]*Ventilation and Air Conditioning, ILK Dresden gGmbH, Dresden, Germany*
[2]*Departamento de Química e Bioquímica, University of Lisbon, Lisbon, Portugal*
[3]*Instituto Politécnico de Tomar, Portugal and Smart Cities Research Center, Tomar, Portugal*
[4]*ILK Dresden gGmbH, Dresden, Germany*
*Matthias.Buschmann@ilkdresden.de*

Reducing net greenhouse gas emissions requires new heat transfer technologies. One such technology could be the use of liquid metals and alloys as heat carriers. For this purpose, the precise knowledge of the thermophysical properties of such materials is of great importance. Our study aims to investigate the temperature dependent density, thermal conductivity, viscosity, and heat capacity of near eutectic gallium-indium-tin alloy.

To model the solid and liquid alloy density, three approaches, weighted fitting of experimental data, modelling based on atomic volumes of alloying elements, and an approach employing excess density, are used. Given the available experimental data and their uncertainty, the fitting functions seem to be the most reliable model between 223.15 and 283.15 K

A specifically developed transient hot-strip method employing a platinum metal-film sensor, produced by physical vapour deposition in a ceramic substrate, and electrically insulated with a heat shrinkable coating is employed to measure thermal conductivity. The measurements are carried out at atmospheric pressure between 301 and 376 K. The estimated uncertainty is 6 %. Measurements show that the thermal conductivity of the alloy correlates linearly with temperature.

Viscosity is measured with a glass Ubbelohde viscometer under an argon atmosphere (281 – 358 K) and an oscillating cup viscometer (292 – 468 K). The cup consists of AISI 316L, a stainless steel high in molybdenum content, to prevent its surface from becoming brittle by the molten alloy contact. Data of both tests are in excellent agreement. An Arrhenius type fitting confirms this behaviour for the alloy between 292 and 468K. The activation energy follows from this fitting with 6.44 kJ $mol^{-1}$.

Specific heat capacity is determined in the temperature range from 236 to 360 K using a Dynamic Scanning Calorimeter µDSC7 evo. Enlarged crucibles, also made of AISI 316L, minimise the relative measurement error. The Kopp-Neumann law agrees well with the data for the solid alloy below 230 K. Between 230 K and the melting point at 283.85 K, an incremental phase solidification may take place. The data for the liquid alloy match reasonably well with most recent literature data. The study provides a discussion of a possible liquid-to-liquid crossover.