Melting curve of indium at high pressure measured by picosecond acoustics

Simon Ayrinhac[1]*, Michel Gauthier[1], Marc Morand[1], Yiuri Garino[1], Silvia Boccato[1], Frédéric Decremps[1], Paraskevas Parisiades[1], Philippe Rosier[1,2], Nicki C. Siersch[1], Abderraouf Seghour[1], and Daniele Antonangeli[1]

[1]*Institut de Minéralogie de Physique des Matériaux et de Cosmochimie (IMPMC), Sorbonne Université, CNRS UMR 7590, Muséum National d'Histoire Naturelle, 4 Place Jussieu, F-75005 Paris, France*
[2]*Laboratoire de Physique des 2 Infinis Irène Joliot-Curie (IJCLab), Université Paris-Saclay, CNRS UMR 9012, 91405 Orsay, France*

Keywords: picosecond acoustics technique, phase diagram, melting line, indium

*e-mail: simon.ayrinhac@sorbonne-universite.fr

Picosecond acoustics (PA) is a time-resolved optical pump-probe technique based on reflectivity measurements used to study the propagation of acoustic waves in a large variety of samples [1, 2]. When associated with resistively heated diamond anvil cell (hDAC), it allows very accurate determination of thermoelastic properties including melting curves and phase diagrams [3, 6]. With such experiments it is possible to simultaneously measure pressure and temperature, transit time or surface phonon imaging, and to deduce the physical state of the sample (liquid or solid) as demonstrated thereafter on indium.

Indeed, although the melting temperature T_M^0 of In is very well known at ambient pressure [4], its melting curve above few GPa measured by several authors using different techniques shows significant discrepancies (see [5] and Figure 1).

In this work, particular care is devoted to the p-T metrology. The accuracy and consistency of the p-T measurements are checked with two *in-situ* calibrants (chromium-doped corundum, α-Al_2O_3: Cr^{3+} and samarium-doped strontium tetraborate, SrB_4O_7:Sm^{2+}) in addition to a thermocouple glued on the rear side of the diamond.

The melting curve is determined using two methods: first with the observation of a discontinuity in the sound velocity upon increasing or decreasing of the pressure at constant temperature [6], second monitoring the p-T liquid and solid phases equilibrium conditions. The latter is usually applied to transparent samples [7, 8], but despite the nontransparency of In, PA technique allows to finely probe its thermodynamical state [3]. Finally, the experimental melting curve is well-fitted [3] up to 6 GPa by a Simon-Glatzel curve

$$T_M(p) = T_{ref}\left(\frac{p - p_{ref}}{a} + 1\right)^{1/c}$$

where a=4.61(11) GPa, c=1.792(34), $p_{ref} = 0$ GPa, and $T_{ref} = T_M^0 = 429.74850(34)$ K [4].

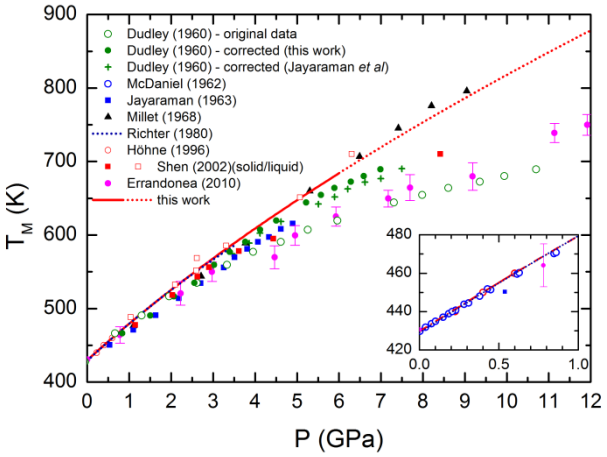

Figure 1. The In melting curve determined using picosecond acoustics (red line), extrapolated above 6 GPa (red dotted line) and compared with the literature data.

[1] F. Decremps *et al*, Ultrasonics, **56** 129 (2015)
[2] S. Boccato *et al*, Phys. Chem. Miner., **49**(6) 1 (2022)
[3] S. Ayrinhac *et al*, Phys. Rev. Mat., **6**(6) 063403 (2022)
[4] H. Preston-Thomas, Metrologia, **27** 3 (1990)
[5] D. Errandonea, J. Appl. Phys. **108**, 033517 (2010)
[6] S. Ayrinhac *et al*, J. Phys.: Condens. Matter, **27** 275103 (2015)
[7] F. Datchi *et al*, Phys. Rev. B, **61** 6535 (2000)
[8] V. M. Giordano *et al*, J. Chem. Phys., **125** 054504 (2006)