

Supplement

(I) Pixel calibration

In pixel calibration of the image, we put a micro-scale slide for optical microscope on the sample stage and measured the scale with 50 μm step in both horizontal and vertical directions. The example of correlation between measured pixel sizes and scale lengths of the micro-scale are shown in Fig. S1a. By fitting the pixel-length relation in Fig. S1a, the pixel size was determined to 3.90(1) $\mu\text{m}/\text{pix}$ (horizontal), and 3.853(4) $\mu\text{m}/\text{pix}$ (vertical).

Image distortion was checked using a micro-scale slide with grid mesh of 500 μm . We measured horizontal and vertical variations of grid mesh sizes in observed image. The results are shown in Fig. S1b. It is confirmed that variation of measured grid sizes are quite small, suggesting that image distortion both in horizontal and vertical directions is negligible.

(II) Analysis procedure of liquid sample

As shown in upper part of Fig. S2, horizontal brightness profile of liquid sample image is scanned to vertical direction. From the scan, apex position, maximum diameter (corresponding sample diameter), and minimum diameter of lower part of the sample (corresponding sample bottom boundary) can be identified.

Since vertical line from apex position corresponds to rotation axis, the sample image is cut to left and right halves. From image analysis of each half image, a half area of sample cross section (S) and position of center of gravity for each half are obtained. Hence, the sample volume is calculated from S and R (distance between rotation axis and center of

gravity) using equation (1).

(III) Alternate expression of melt (defect) fraction in solid Sn near T_m

According to Delogu (2006) and Manai and Delogu (2007), they considered that the premelting effect is connected with rapid increase of defectively coordinated atoms or lattice defects. Martrell et al. (2013) also reported that atomic defects are a good indicator of how close the system is from melting and how the melt propagates into the solid structure. If we assume that the defectively coordinated atoms can be represented by the atomic configuration in liquid, the density in the premelting region (ρ) is expressed as;

$$\rho = (1 - x)\rho_{Solid}(T) - x\rho_{Liquid}(T) \quad (3)$$

where x is a fraction of defect or melt. $\rho_{Solid}(T)$, $\rho_{Liquid}(T)$, and ρ are solid density, liquid density, and measured density, respectively. The extrapolated value from the linear trend before the premelting is used for the value for $\rho_{Solid}(T)$. The reported liquid density by Touloukian et al. (1975) was used for the $\rho_{Liquid}(T)$. The variation of x of Sn as a function of temperature is shown in Supplemental¹ Fig. S5. The x gradually increases from 0.01 at 493 K ($T/T_m = 0.98$) to 0.2 at 505 K and suddenly jump to 1. This may indicate that the fraction of defect in solid Sn increases to 0.2 by the premelting effect.