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The Structure of Liquid-vapor Interface of Ga:Sn:Pb Alloys

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Beamline(s): X19C

Introduction: In the interface of dilute lead-gallium alloys, excess Pb forms a monolayer at the temperature range 23-76°C. The Pb monolayer is in a two-dimensional hexagonal crystalline state below 66°C. The existence of the crystalline state is well understood, based on the GIXD studies, which shows sharp peaks. The structure of the more disordered phase at higher temperatures and the nature of the phase transition were not well understood yet, therefore, we studied the liquid-vapor interfaces of three lead-tin-gallium alloys by GIXD and XR.

Methods and Materials: Grazing incidence X-ray diffraction and X-ray reflectivity; Pb, Sn, and Ga.

Results: For two alloys with lower tin concentrations, a first-order phase transition is found. Below the transition point, four sharp peaks are found in GIXD, and the peak positions are corresponding to the 2-D hexagonal crystalline pattern. For the highest tin concentration we studied, no crystalline monolayer is found within our temperature range. When the Pb monolayer is crystalline, XR results show that the surface coverage is 100%. The surface coverage drops, when the temperature is higher than the transition point, or when the tin concentration becomes higher. Some GIXD and XR results are shown in Fig1 and Fig2.

Conclusions: Pb forms a monolayer in the interface, and the monolayer is crystalline at lower temperature, when the tin concentration is low. For our three alloys, we found the melting points of the Pb monolayer are respectively $67.8 \pm 0.1^\circ\text{C}$, $40.6 \pm 0.1^\circ\text{C}$, and below 30°C (not observed). For the crystalline monolayer, the GIXD peak intensity varies a lot. This is most likely due to large domain sizes, and we found the domain size of our crystalline monolayer could be as large as 0.7 μm .

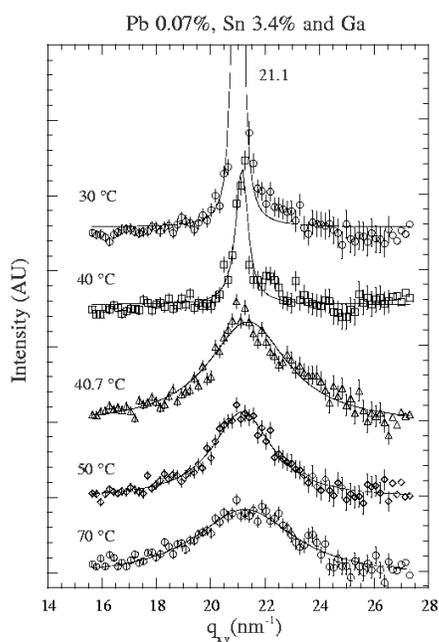


Fig1. GIXD pattern for one alloy around the first diffraction peak of the Pb monolayer

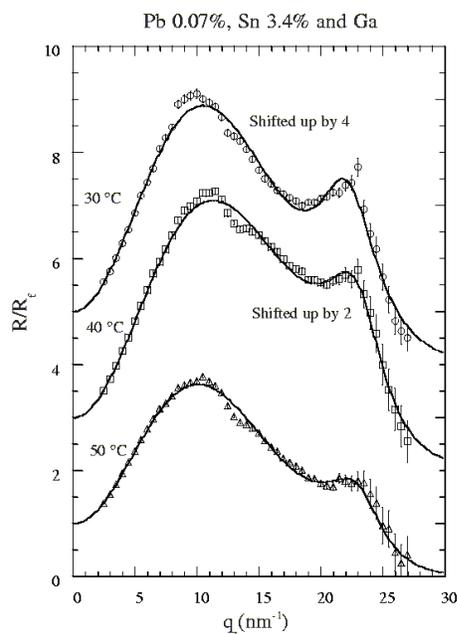


Fig2. X-ray reflectivity data and model fits for one alloy studied.