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Structural studies of Sn thin films deposited on InSb at cryogenic temperatures

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Tin (Sn) has two crystalline phases, α-Sn and β-Sn, in which α-Sn is a cubic semimetal with quasi-zero bandgap and β-Sn is a tetragonal crystal and a superconductor with a critical temperature of 3.7K [1]. α-Sn is stable below 13°C, whereas β-Sn is stable above 13°C. InSb is one of the highest electron mobility semiconductors with strong spin-orbital coupling. Interestingly, the crystal lattice of InSb matches the α-Sn lattice and recent studies demonstrated that epitaxial α-Sn on InSb can be stabilized above 13°C [2]. Surprisingly, we recently observed that β-Sn layers can form on InSb nanowire facets at cryogenic temperatures, those hybrid structures being an ideal platform to study topological superconductivity.[3]

In this context, we propose to study more in details the formation of Sn on InSb(110), which corresponds to the facets of InSb nanowires. We deposit Sn thin films on InSb(110) at 80K in a molecular beam epitaxy (MBE), in which the low deposition temperature ensures the wetting of the Sn layer and the formation of a smooth thin film on InSb. To prevent the oxidation and the dewetting of Sn, an additional thin AlOx layer is deposited in-situ while the sample is still cold. We study the influence of the deposited thickness on the crystalline quality of the Sn thin film. In X-ray diffraction (XRD), the out-of-plane geometry reveals the crystallinity along the growth direction. We observe all the thin films have the α-Sn phase and are epitaxial on InSb regardless of the studied thickness. The in-plane geometry reveals the in-plane crystallinity. In this configuration, we observe β-Sn grains in the thin film with two preferable orientations. The β-Sn grains might be responsible to the superconducting behavior of the Sn thin film at low temperature measurement. Future studies of in-situ monitoring of the growth by grazing incidence XRD will allow us to understand how those β-Sn grains form and propagate in the α-Sn phase. Finally, our study unravels the relationship between the crystalline structures of Sn and their electronic transport properties.

References

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