Low Temperature MBE Growth and Characterization of (111) $Sn_{1-x}Mn_xTe$ Thin Epitaxial Layers Obtained with Additional Te Flux

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Intriguing multifunctional properties make Mn-doped SnTe a promising candidate for next-generation low temperature spintronic devices. This material exhibits an attractive interplay of topological insulating behavior, magnetism, and ferroelectricity. This unique combination allows for the potential manipulation of one property by altering another, opening exciting avenues for device functionality.

This work is devoted to the low temperature growth and characterization of $Sn_{1-x}Mn_xTe$ (x_{Mn} = 0-0.07) epitaxial films. They were grown on BaF_2 (111) substrates [1] using molecular beam epitaxy (MBE) with varying Mn and Te fluxes. Films have the thickness ranging from 20 to 100 nm and were characterized using various techniques, including *in-situ* RHEED, HR-XRD and AFM. The thin films were obtained using two-step method. In the first step, a continuous single crystalline film with a rough surface was formed at a reduced substrate temperature. This initial layer was formed by the rapid coalescence of *Volmer-Weber* islands. A rapid annealing step at a higher temperature was then implemented. This stage resulted in the formation of thin epitaxial layers with an extremely smooth surface (RMS roughness ~ 275 pm). The rationale for the two-step process is the relaxation of strains within the film during the initial island formation stage. This relaxation allows surface energy minimization to become the dominant driving force during the high-temperature annealing step. Consequently, increased surface diffusion at this elevated temperature actively promotes surface smoothing.

We have found that the growth of these thin films with an excess Te induces a tetragonal strain-induced distortion of the crystal structure. This distortion increases with increasing Te content and can cause significant in-plane compressive strain ($\varepsilon_{\parallel}$ ~ -0.6%) and out-of-plane lattice expansion ($\varepsilon_{\perp}$ ~ 0.7%). These significant strains have the potential to shift energy bands, enabling the design of novel valleytronic devices that exploit valley degree of freedom for information storage and processing. Additionally, magnetotransport measurements revealed hole-mediated ferromagnetism in samples with $0.03 \leq x \leq 0.07$, with the highest critical temperature (T_C) of 7.5 K observed for $Sn_{1-x}Mn_xTe$ [2].

This research paves the way for tailoring the multifunctional properties of Mn-doped SnTe thin films, making them promising candidates for advanced spintronic and valleytronic devices.

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