Quantum Hall effect and Shubnikov-de Haas oscillations in the topological crystalline insulator quantum wells

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Recent advances in materials quality have enabled the observation of the quantum Hall effect (QHE) in topological insulators. The unique characteristics of the two-dimensional (2D) system formed by the topological surface states strongly affect the behavior of the QHE states. While most studies has focused on systems protected by time-reversal symmetry, this work explores the QHE in topological crystalline insulators (TCIs) protected by crystal symmetries. One of the intriguing aspects of the QHE in TCIs is the impact of strain engineering [1], as well as the anticipated emergence of nematicity in the degenerate Landau levels in high magnetic fields [2, 3].

To achieve the conditions for observing QHE states, (111) TCI quantum wells (QWs) with a nominal composition of $Pb_{0.75}Sn_{0.25}Se/Pb_{0.90}Eu_{0.10}Se$ with different widths were grown by molecular beam epitaxy. QWs were doped with Bi to achieve lower carrier density. After growth and initial characterization, obtained heterostructures were lithographically processed in the form of L-shaped Hallbars to probe quantum transport properties for two perpendicular crystallographic directions: [112] and [110].

Strong Shubnikov-de Haas (SdH) oscillations are observed below 1 T, indicating the high-quality of the structures obtained. In high magnetic fields, Hall resistance, measured up to 36 T, develop pronounced QHE plateaus. We have studied SdH oscillations and QHE plateaus evolution as a function of temperature (1.6-25 K) and tilting angle (0^o-90^o). This allowed us to extract important material parameters, such as the SdH oscillations phase and cyclotron mass. Notably, we did not observe anisotropy of the quantum transport properties, probed along [112] and [110]. We have described our results in terms of a 4-band $\boldsymbol{k \cdot p}$ model. A detailed comparison of the model's predictions with experimental data will be presented.

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