Quantized Hall conductance in the quantum wells based on topological crystalline insulator

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The quantum Hall effect (QHE) is a fascinating phenomenon that is heavily influenced by the properties of the material that contains a 2D electronic system. While topological insulators have been found to exhibit QHE due to their topological surface states, topological crystalline insulators (TCIs) have not yet displayed this effect. The difference between those classes of materials is that topological protection occurs due to time-reversal symmetry in topological insulators, whereas in TCIs, it occurs due to crystal mirror symmetry. Owing to the peculiarities of its band structure, QHE in TCI can be influenced by strain engineering [1] and also exhibit nematic QHE at high magnetic fields [2,3].

In this study, a 2D system was fabricated by molecular beam epitaxy of a $Pb_{0.75}Sn_{0.25}Se$ quantum well, embedded between $Pb_{0.90}Eu_{0.10}Se$ barriers. This was achieved by molecular beam epitaxy. $Pb_{1-x}Sn_xSe$ is known to be TCI when it contains sufficiently high Sn content (x_{Sn}>0.15), but it is prone to becoming p-type due to Sn vacancies. To address this issue, Bi dopant was added to compensate for background doping. After an initial magnetotransport characterization, L-shaped Hallbars were patterned of the quantum wells structures using optical lithography and wet etching. This allowed us to study the magnetotransport properties in two orthogonal crystallographic directions: [112] and [110].

The low magnetic fields (<1 T) Shubnikov-de Haas (SdH) oscillations confirms a good quality of the grown heterostructures. At high fields (up to 36 T), well-developed plateaus in R_{xy}, together with near-zero values of R_{xx}, indicate QHE states and provide information on the degree of valley degeneracy. However, no dependence on crystallographic orientation was observed. We extracted a number of material parameters such as the phase of SdH oscillations and the cyclotron mass, by investigating the evolution of magnetotransport properties with temperature (from 1.6 up to 25 K) and tilt angle (0 to 90°). A 4-band $\boldsymbol{k \cdot p}$ model was used to interpret and analyze the obtained results. Overall, this work highlights the potential of TCIs for exploring QHE with potentially unique features compared to conventional 2D systems and TI's surface states.

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