2D Hole Gas in (111) $Pb_{0.75}Sn_{0.25}Se/Pb_{0.90}Eu_{0.10}Se$ Quantum Wells explored by Magneto-Transport

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Topological materials exhibit quantum phenomena that are key to advances in quantum computing. Within this broad class, topological crystalline insulators (TCIs) offer interesting properties due to the multivalley nature of their band structure. Despite the significant potential of IV-VI TCIs in controlling TI phases by strain engineering [1] and the realization of nematic quantum Hall effects (QHE) at high magnetic fields [2], their quantum transport properties remain relatively unexplored.
In this study [3], we have obtained by molecular beam epitaxy a two-dimensional hole gas (2DHG) in TCI $Pb_{0.75}Sn_{0.25}Se:Bi/Pb_{0.90}Eu_{0.10}Se$ quantum wells (QWs) with thicknesses between 10 and 50 nm. Following Hall bar fabrication, we investigated magnetotransport properties along two crystallographic directions: [112] and [110]. Low-field Shubnikov-de Haas oscillations (SdHO) confirmed the high quality of the heterostructures, weak anti-localization (WAL) and universal conductance fluctuations (UCF) revealed strong spin-orbit coupling and long phase-coherence times. At high magnetic fields, well-defined QHE plateaus in the Hall resistance and near-zero longitudinal resistance were observed. By analysing the temperature and tilt-angle dependencies of SdHO and QHE, we extracted key material parameters, including the SdHO phases and cyclotron masses. Notably, the quantum transport behaviour is independent of crystallographic orientation. A four-band *k·p* model was employed to interpret our findings and allowed to obtain the topological phase diagram. Our work indicates that further progress in controlling Sn content, carrier densities, and magnetism in TCI QWs will result in observation of quantized topologically protected edge transport even in the absence of an external magnetic field.

References

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Figures

Figure 1: (a) QHE in 10 nm $Pb_{0.75}Sn_{0.25}Se$ QW ; (b) Normal insulator (NI) – quantum spin Hall (QSH) insulator transitions as a function QW thickness and Sn content

This research was partially supported by the "MagTop" project (FENG.02.01-IP.05-0028/23) carried out within the "International Research Agendas" programme of the Foundation for Polish Science co-financed by the European Union under the European Funds for Smart Economy 2021-2027 (FENG); and by Narodowe Centrum Nauki (NCN, National Science Centre, Poland) IMPRESS-U Project No. 2023/05/Y/ST3/00191. The project was co-financed by funds from the state budget allocated by the Minister of Science (Polska) as part of the Polish Metrology II programme. V.V.V. acknowledges long-term program of support of the Ukrainian research teams at the Polish Academy of Sciences carried out in collaboration with the U.S. National Academy of Sciences with the financial support of external partners. Measurements at high magnetic fields were supported by LNCMI-CNRS, members of the European Magnetic Field Laboratory (EMFL) and by the Ministry of Education and Science, Poland (grant no. DIR/WK/2018/07) via its membership to the EMFL.