# Electron Transport Properties of $Pb_{0.7}Sn_{0.3}Se$ Irradiated with Electron Beam


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As it is known, bulk $Pb_{1-x}Sn_xSe$ crystals belong to widely investigated crystalline topological insulators [1]. However as-grown crystals have huge free carrier concentration which completely masks expected electric conductance of the surface topological states. Our motivation was, by means of introducing radiation defects, to eliminate, as much as possible, bulk conductance of the crystal, to favor its topological surface conductance.

Here we report on transport study of an irradiated bulk $Pb_{1-x}Sn_xSe$ monocrystal obtained by self selecting vapour growth method. The composition x=0.30 was chosen to ensure that at low temperatures the sample would have inverted band structure, i.e. it should really be a topological insulator. Before irradiation the sample was n-type with high free electron concentration of about $1\times10^{18}$ $cm^{-3}$. By controlling the beam dose one can tune bulk conductivity from n-type to p-type, thus crossing through the sample state which would be very close to an intrinsic one. The crystal was irradiated with 2.5 MeV electron beam. Electron irradiations were carried out in NEC Pelletron – type electrostatic accelerator configured with a low temperature target maintained at 20 K in a chamber filled with liquid hydrogen. For the sample which after irradiation appeared to be close to intrinsic one (used for the experiments described below), electron irradiation dose was equal to 50 $mC/cm^2$.

The sample was investigated at temperatures ranging from 1.5 K to 300 K and magnetic field *B* up to 12 T. Low-field Hall constant and Hall mobility as well as (at selected temperatures) resistivity tensor was measured versus *B*.
We have found that:

1. The sample was practically intrinsic down to approximately 100 K – this was confirmed by the mobility spectrum analysis (MSA) and multicarrier fittings of the magnetic field dependence of the conductivity tensor compared with the calculation of the intrinsic concentration versus temperature;
2. Even at the lowest temperatures the conductivity was clearly seen, although it represented some other than mobile carrier-related conductivity channel (disorder-related? or hoping?)
3. At temperatures below 20 K and weak magnetic fields below 0.2 T some magnetoresistance structure resembling weak antilocalization was seen;
4. Rotating the sample with respect to the magnetic field did not influence the shape of the above mentioned structure, thus proving that it was not related to two-dimensional electronic object (i.e. not the topological surface states).
5. At temperatures between 50 K and 90 K and at strong magnetic fields above 10 T some negative magnetoresistance was observed. A description of this effect is beyond the scope of the MSA model.

In conclusion we have not seen any evident signatures of the conduction through surface topological states, although the sample seemed to be optimal from this point of view.


[1] P. Dziawa et al., *Nature Materials* **11**, 1023–1027 (2012).