

## **Project 4.5: MBE growth and characterization of topological crystalline insulator nanowire heterostructures (experimental)**

**Supervisor:** dr hab. Janusz Sadowski

**Institute:** IFPAN

**Unit:** ON1.2

**WWW:** <http://info.ifpan.edu.pl/sdvs/pl/on1.2.html>

### **Background:**

The selected candidate will participate in the realization of the OPUS project financed by National Science Centre Poland, „Radial nanowire heterostructures of topological crystalline insulators with superconductors, ferro- and antiferromagnets”. The project is focused on realization and investigations of core-shell nanowire heterostructures consisting of topological crystalline insulator (TCI) nanowire (NW) cores encapsulated by the shells of ferromagnetic (FM) antiferromagnetic (AFM); and superconducting (SC) materials.

Topological insulators (TI) constitute a “hot topic” in condensed matter physics over the last decade - the 2016 physics Nobel Prize was granted for “Theoretical discoveries of topological phase transitions and topological phases of matter”.

Charge carriers at the surface of TI behave similarly to those in graphene, but unlike the latter they also maintain distinct spin orientation. Due to this, in heterojunctions, magnetic material (FM or AFM) can affect the properties of TI and/or vice versa. In nanowires these effects are expected to be much stronger than in a 2D (layer) case, because of their high surface to volume ratio.

In the case of TI nanowires interfaced with SC material, so called Majorana fermions can occur. Due to their unique properties these composite quasiparticles can be used as Q-bits for quantum computing applications.

### **Aim:**

The PhD student will be involved in the molecular beam epitaxy (MBE) growth and basic characterisation of TCI nanowire core-shell heterostructures. The specific materials used in the project are: (Pb,Sn)Te IV-VI narrow bandgap semiconductor as a TCI core material; (Pb,Sn,Mn)Te dilute magnetic semiconductor as a ferromagnetic shell; MnTe as an antiferromagnetic shell; Pb as a superconducting shell.

The first stage of the project will be to optimize the MBE growth of (Pb,Sn)Te nanowires with composition, resulting in TCI properties (using the expertise of the ON.1.2 research group at IP PAS). Further steps will consist in realization (also by the MBE growth) of core- shell NW heterostructures specified above.

Beside the MBE growth the PhD student will participate in characterization of the NW samples (in cooperation with other contractors of the OPUS project) using scanning and transmission electron microscopy techniques, and low temperature magnetotransport measurements.

### **Requirements:**

- Master's degree in physics, materials science, or nanotechnology
- knowledge of physics of semiconductors

- basic experience in thin film deposition techniques – preferably molecular beam epitaxy
- knowledge of crystallography and physics of nanostructures
- ability to work as a team member and effectively communicate
- good spoken and written English.
- passion for experimental work

**Funding:**

Scholarship: grant funding of 5000 PLN per month, before subtracting obligatory employer and employee social security contributions (~15%), for 44 months. Afterwards, standard Polish PhD scholarship 3240 PLN/month net in additional 4 months.

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