



PhD in FISICA / PHYSICS - 38th cycle

THEMATIC Research Field: LARGE-AREA TOPOLOGICAL INSULATORS FOR NOVEL SPIN-CHARGE INTERCONVERSION APPLICATIONS

Monthly net income of PhDscholarship (max 36 months)

€ 1250.0

In case of a change of the welfare rates during the three-year period, the amount could be modified.

Context of the research activity

Motivation and objectives of the research in this field

Topological insulators (TIs) are gaining a huge attention from a technological point of view due to highly efficient spin-charge interconversion (SCIC) phenomena occurring at their interfaces, which is of interest for spin-orbit torque MRAM and novel processing-in-memory devices such as the MESO proposed by Intel. Being SCIC phenomena at the core of the operation of basically all so-far proposed spintronic devices based on TIs, to develop methods allowing to probe SCIC in the most efficient way is demanding. The final objective of this research activity is to probe the spinresistance given by the SCIC in the TIs, i.e., the electrical resistance variation induced by a spin population externally injected inside the TI. Achieving such spin-based control of an electric signal by exploiting the unique SCIC properties at TIs interfaces would allow to devise a spinresistance-based logic gate with, in principle, low seek of energy switching. Intermediate objectives of the research activity will be (i) the growth of TIs over large-area substrates by making use of metal-organic chemical vapour deposition (MOCVD), which being already widely employed in industry, is thought a viable option towards the future TIs technology-transfer; (ii) the thorough investigation of the developed TIs to correlate their topological character with materials' quality and properties; (iii) the fabrication of the thin films of TIs grown by MOCVD to probe SCIC phenomena in TIs by using non-local and ferromagnet-free optical methods.

Methods and techniques that will be developed and used to carry out the research

1. Growth of large-area TIs will be achieved by metal-



research	<p>organic chemical vapour deposition (MOCVD).</p> <p>2. Developed TIs will be first characterized from the point of view of their structure and morphology, mainly by scanning electron microscopy (SEM), X-ray diffraction and reflection (XRD, XRR), and atomic force microscopy (AFM).</p> <p>3. The validation of the TI's topological properties will be done by magnetotransport.</p> <p>4. Fabrication of large-area TIs will be performed exploiting lithographic techniques.</p> <p>5. SCIC in the developed TIs will be investigate optically in non-local and ferromagnet-free geometries.</p> <p>6. The spinresistance phenomenon will be probed via optical, and eventually electrical, techniques.</p> <p>Activities 1,2,3 will be mainly carried out at the CNR-IMM. Unit of Agrate Brianza (inside ST Microelectronics).</p> <p>Activities 4,5,6 will be mainly carried out at the Physics Department of Politecnico di Milano.</p>
Educational objectives	<p>There will be constant feedback between SCIC functionality and TIs growth and quality, constituting a 360° loop within which the candidate will learn the basics of:</p> <p>(i) TIs physics,</p> <p>(ii) MOCVD growth,</p> <p>(iii) materials' comprehensive structural/chemical/morphological investigation,</p> <p>(iv) spintronics and spin-based device's functionalities.</p>
Job opportunities	<p>The skills acquired in these activities will represent an important cultural background that could disclose international opportunities not only at the academic level but also for highly qualified positions in the Hi-Tech job market. In this respect, previous PhD of the group are nowadays proceeding their research carrier either in universities or factories.</p>
Composition of the research group	<p>3 Full Professors 1 Associated Professors 5 Assistant Professors 3 PhD Students</p>
Name of the research directors	<p>R.Mantovan, C. Wiemer, M.Finazzi, C.Zucchetti</p>



Contacts

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Additional support - Financial aid per PhD student per year (gross amount)

Housing - Foreign Students	--
Housing - Out-of-town residents (more than 80Km out of Milano)	--

Scholarship Increase for a period abroad

Amount monthly	625.0 €
By number of months	6

Additional information: educational activity, teaching assistantship, computer availability, desk availability, any other information

Educational activities The candidate will follow the educational activities provided by the PhD school of Politecnico di Milano. Moreover, the participation to international schools and conferences in the field of spintronics, magnetism and material science will be strongly encouraged.

Teaching assistantship: There are various forms of financial aid for activities of support to the teaching practice. The PhD student is encouraged to take part in these activities, within the limits allowed by the regulations.

Computer and desk availability: *individual or shared use*