UNIVERSITÀ DI TRENTO | Department of Physics

A Quantum of Matter

Overcoming 2D materials' limits with 3D structures: synthesis of MoS_2 by Ionized Jet Deposition

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Transition metal dichalcogenides (TMDs), though being well known in the past for dry lubrication and hydrodesulfurization catalysis, have an increasing interest mainly related to the discovery of graphene, a two-dimensional (2D) carbon crystal exhibiting properties that are not present in bulk graphite. Indeed, TMDs show a similar layered structure, but going from 3D to 2D, an indirect-to-direct band gap occurs due to quantum confinement effects, leading to an enhanced photoluminescence ideal for light-emitting diodes, solar cells, and photodetectors. Moreover, a high electron mobility and superior on/off current ratio make them ideal for high-performance electronic devices.
The main limits for using TMDs arise from the difficulties in realizing large and defects-free single layers. Exfoliation from bulk material is the most accessible approach, but a bottom-up method is highly desirable for large-scale production. In this sense, Chemical Vapor Deposition (CVD) is the most promising technique, but it still suffers from the need to transfer the synthesized single layer from the original substrate to the final device structure. MoS_2 is probably the most investigated TMD, and we selected this material to study its synthesis using a new approach, Ionized Jet Deposition (IJD). We achieved very good results in terms of electronic and optical properties, finding the direct band gap and intense photoluminescence in a 100nm thick film, i.e., the single-layer properties in a 3D structure, overcoming the thickness-related limitations of 2D MoS_2. The most recent results and perspectives for synthesizing other TMDs by IJD will be presented.

Who is Roberto Verucchi?
Roberto Verucchi achieved a degree in Physics (1991, Univ. of Modena, Italy) and a Ph.D. in Physics (1996, Univ. of Parma, Italy). He was a Technologist at the National Institute of Matter Physics, INFM (1998-2000), and then a Researcher at the Institute for Photonics and Nanotechnology IFN-CNR (2000-2010) and Institute of Materials for Electronics and Magnetism, IMEM-CNR (2010-today). He is currently a Senior Researcher at IMEM-CNR, responsible for the Trento unit. His interests lie in materials science, physics/chemistry of surfaces, with particular attention to growing nanostructured materials and their study using surface electron spectroscopies and microscopies. The most recent activities are the synthesis of 2D nanostructured transition metal dichalcogenides and metal oxides and the study of carbon-based 2D materials.

A Quantum of Matter is a series of events dedicated to the research in Physics of Matter that is carried out in the **Physics Department of the University of Trento**. The goal of **A Quantum of Matter** is to develop synergies and collaborations between research groups: for this reason, the seminars will focus not only on the results obtained, but also on the techniques employed by the groups and on the possible research themes that could be developed in partnership, leaving plenty of room for exchange of opinions and discussion.

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