Politecnico di Torino | DET

Seminar

From Bonds to Bands: (Opto-)Electronic Properties of Chalcogenides for Data Storage and Energy Conversion

Matteo Cagnoni

Date: Wednesday, June 16th 2021, 15:00
Place: https://zoom.us/j/92178195339?pwd=UkF3NTEzY1JteURoNTQ5VU1EamNRdz09
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Abstract

Chalcogenides form a vast material class, which comprises compounds with very interesting and diverse chemical and physical properties. They are applicable in a broad range of technologies, such as data storage, energy conversion, infrared detection, high-mobility thin-film transistors and spintronics, and count among their ranks materials with exceptional properties, including superconductors and topological insulators.

The seminar discusses chemical and physical properties of chalcogenides for optical data storage, non-volatile electronic memories and thermoelectric power generation. After a short introduction to the key concepts of such applications and to chalcogenide materials, structural and chemical properties of group IV and group V chalcogenides, collectively referred to as p3 chalcogenides, are presented; state-of-the-art materials for data storage and thermoelectric energy conversion belong to this sub-class. Next, the interplay between the nature of the chemical bond and opto-electronic properties relevant to data storage applications is discussed. A treasure map is presented, which predicts which p3 chalcogenides are suitable for data storage applications and enables pre-optimization of their properties. Extension of the approach to other material classes is discussed. Finally, such classification scheme is adopted to discuss the application of p3 chalcogenides to thermoelectric power generation. It is shown how the nature of the chemical bond is closely related to the thermoelectric performance, by means of experimental quantification of Fermi surface complexity and "band linearity" in combination with tight-binding and k·p modeling of the electronic structure. Design rules are defined that link chemical bonding properties to thermoelectric performance and enable the discovery of high-efficiency thermoelectric materials.

Biography

Matteo Cagnoni received his bachelor's degree in Computer Science and Electronic Engineering from University of Perugia, Italy, in 2012, his master's degree in Nanotechnologies for ICTs from Polytechnic University of Turin, Italy, in 2014, and his doctoral degree in Physics from RWTH Aachen University, Germany, in 2019. His research interests include design of solid-state materials for data storage and renewable energy applications. He has developed his master's thesis on chemical-physical properties of perovskites for photovoltaic applications at Tohoku University, Japan. He has been working on chalcogenides for phase-change memories and thermoelectric energy conversion during his doctoral research, with focus on experimental characterization and theoretical modeling of the interplay between chemical bonding, band structure, charge/thermal transport and optical properties, aimed at tailoring properties to the applications of interest. He has been working for Intel Corporation's subsidiary IMS Nanofabrication GmbH, Austria, as Physical Modeling and Simulation Engineer and Patent Analyst from August 2019 until May 2021, where he has acquired expertise on Finite Element Methods and design of electromagnetic components for charged-particle optics. From July 2021, Matteo Cagnoni will join the Department of Electronics and Telecommunications (DET) of Polytechnic University of Turin, Italy, as Postdoctoral Research Fellow within the H2020 MIRACLE (Photonic Metaconcrete with Infrared RAdiative Cooling capacity for Large Energy savings) project.

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