

PhD course in Physics and Nanoscience - XXXVII cycle

1st year report – Ermes Peci

Supervisors: Dr. F.Bisio and Prof. M.Canepa

RESEARCH ACTIVITIES

The central topic of my first-year Ph.D. research activity has been the investigation of two-dimensional systems made of transition metal dichalcogenides (TMDCs), such as WS_2 and MoS_2 . These atomic-thick materials exhibit intriguing optical and electronic properties, and they can be exploited as functional layers in novel devices.

My work involved the characterization of mono- and few-layer structures and is aimed at understanding how the interplay between subsequent layers modifies the dielectric behavior of each structure. In particular, I studied the properties of folded CVD-grown WS_2 flakes having different stacking orientations and different degrees of coupling between subsequent layers. This work required an extensive characterization of the samples, involving photoluminescence and Raman spectroscopy, traditional and imaging spectroscopic ellipsometry, micro-transmittance spectroscopy, atomic force microscopy, and, in collaboration with E.Stratakis' group at FORTH (Crete), second-harmonic generation spectroscopy. During this investigation I also participated to the installation and testing of the new accurion_ep4 imaging ellipsometer at DIFILAB.

Another activity has been the preliminary characterization (photoluminescence, Raman, X-ray photoemission spectroscopies, and spectroscopic ellipsometry) of substrates and synthesized monolayers of MoS_2 in collaboration with V.Derycke's group at Université Paris-Saclay. This collaboration has the final goal of studying the charge dynamics of MoS_2 through an integrated analysis involving backside absorbing layer microscopy and imaging ellipsometric measurements on voltage-gated systems.

The third project I worked on is the gold-assisted mechanical exfoliation of large-area (tens of mm^2) monolayers of WS_2 and MoS_2 . This would allow to easily make batches of samples of TMDCs with large area and high crystalline quality, overcoming the limitations in size, quality, and quantity of other techniques, like chemical vapor deposition or scotch-tape exfoliation. At present, a point of investigation is the best functionalization of the final substrate, i.e., the one which gives the best results in terms of size and quality of the transferred monolayer.

Other activities performed during this year include the assembly, integration, and testing of an ultra-high vacuum chamber for a spectroscopic ellipsometer, which would allow to perform temperature-dependent measurements and real-time monitoring of ion bombardment processes, and the implementation of a LabVIEW control software for a pump-probe spectroscopy setup.

CONFERENCES AND SCHOOLS

ICSE-9, 9th International Conference on Spectroscopic Ellipsometry, May 22-28, 2022 (held online).

Epioptics-16 & X-enes 4, International School of Solid-State Physics, Erice (Italy), July 3-9, 2022. Poster presentation: *Probing the dielectric function of two-dimensional tungsten disulfide in homo- and heterobilayer stacking*

108th National Congress of the Italian Physical Society, Milano (Italy), September 12-16, 2022.

Oral presentation: *Dielectric properties and exciton tunability of two-dimensional WS₂ in van der Waals bilayers*

PUBLICATIONS

Submitted article:

E.Peci, M.Magnozzi, L.Ramò, M.Ferrera, D.Convertino, S.Pace, G.Orlandini, A.Sharma, I.Milekhin, G.Salvan, C.Coletti, D.R.T.Zahn, F.Bisio, M.Canepa, *Dielectric Function of Two-Dimensional Tungsten Disulfide in Homo- and Heterobilayer Stacking*

In preparation:

P.Canepa, E.Peci, et al., *Surface Patterns on CVD-Grown Monolayer WS₂ Flakes: an investigation with AFM Adhesion and Friction signals*

PHD COURSES

Applied Cryogenics (Dr. R.Musenich) – exam passed

Quantum Optics (Dr. D.Ferraro)

Biosensing (Dr. E.Angeli and Prof. O.Cavalleri)

TUTORING

Teaching assistant (30 hours) for the 2nd semester of the “General Physics” course, B.Sc. in Biomedical Engineering, Università di Genova. Exercises at the blackboard (thermodynamics, electromagnetism) and tutoring activity.