PhD course in Physics and Nanoscience - XXXIX cycle

1st year report – Emma Spotorno

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

RESEARCH ACTIVITIES

For the first part of the year, I've been focusing on the investigation of hybrid materials composed of transition metal dichalcogenides (TMDCs) combined with the plasmonic metal nanoparticles. These materials exhibit fascinating optical and electronic properties in their two-dimensional form. One of the most interesting features of TMDCs, for our purposes, is their temperature dependent photoluminescence response. Indeed, the goal of the first semester of my first-year PhD research activity has been to couple the TMDCs monolayer and nanoparticles to create a nanothermometer. The built system exploits the thermoplasmonic effect in Au nanoparticles for heat generation, and the temperature-dependent optical response of monolayer TMDC to measure the temperature less than 1 nm away from the particle surface.

To obtain large area monolayer of TMDC I exploited an innovative technique called "Gold assisted exfoliation" and then, characterized the exfoliated samples with photoluminescence and Raman spectroscopy, spectroscopic ellipsometry and X-ray photoelectron spectroscopy.

To be able to nano-manufacture nanoparticles on top of the TMDCs, at the beginning of my PhD, I learned to use the Nanfrazor tool, a lithography system of naonofabrication.

In the second semester, my PhD research has been focused on daytime radiative cooling, a passive process that exploits photonic effects to radiate energy away from a system at room temperature on Earth surface towards outer space, while simultaneously avoiding solar heating, all any energy input. The radiative coolers are composed of a layer reflecting almost the entire solar spectrum and a layer emitting in mid-infrared region. The first layer prevents the radiative cooler from heating up under sunlight, while the second layer radiates its heat through the atmosphere to the cold outer space. This is possible because the spectral peak of black body radiation at room temperature coincides with the transparency window of the atmosphere (8–13 μm). The project about radiative coolers was realized in a collaboration between Unige, Politecnico di Torino, Politecnico di Milano and CNR-Scitec. My work involved assembling and integrating an insulating box to be able to measure the temperature of samples under sunlight. I developed a LabVIEW program for the acquisition of the temperature difference between sample and environment using a thermocouple. I then tested the setup using a silicon wafer with a reflective layer of silver deposited on top. The silver layer was obtained by the e-beam deposition technique. After the deposition, I characterized the samples using spectroscopic ellipsometry. I've also began the characterization of the first samples of photonic crystals, manufactured by Politecnico di Milano, which will be used as reflective layers of the radiative cooler.

CONFERENCES AND SCHOOL

- Plasmonica International School on Plasmonics and Nano-optics, June 3-7, Como, Italy, 2024. Poster presentation: *Non-Invasive Deterministic Plasmonic Nanostructures Lithography on 2D Transition-Metal Dichalcogenides*
- The International Meeting on Nanoalloys 2024 (IMN 2024), September 2-5, Genoa, Italy. Talk presentation: *Plasmonic Metal Nanostructures on Excitonic Systems for Nanothermometry*

PUBBLICATIONS

Published article:

Petrini, Nicolo'; Peci, Ermes; Curreli, Nicola; Spotorno, Emma; Kazemi Tofighi, Nastaran; Magnozzi, Michele; Scotognella, Francesco; Bisio, Francesco; Kriegel, Ilka, *Optimizing Gold-Assisted Exfoliation of Layered Transition Metal Dichalcogenides with (3-Aminopropyl)triethoxysilane (APTES): A Promising Approach for Large-Area Monolayers*. Advanced Optical Materials, 2024, 2303228.

Submitted article:

Ramò, Lorenzo; Peci, Ermes; Magnozzi, Michele; Spotorno, Emma; Venturino, Valentina; Sygletou Maria; Giordano, Maria Caterina; Zambito, Giorgio; Telesio, Francesca; Milosz, Zygmunt; Canepa, Maurizio; Bisio, Francesco, *Non-Invasive Deterministic Plasmonic Nanostructures Lithography on 2D Transition-Metal Dichalcogenides*.

PhD COURSES

Computational physics (Prof. Ferrando) – exam passed

Applied Cryogenics (Dr. Musenich)

TEACHING ACTIVITY

Assistance for high school students visiting the Physics Department: graphene exfoliation and investigation of its optical properties using Raman spectroscopy and spectroscopic ellipsometry.