PhD course in Physics and Nanoscience - XXXIX cycle

2nd year report – Emma Spotorno

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

RESEARCH ACTIVITIES

In the second year of my PhD, my 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 the Earth surface towards outer space, while simultaneously avoiding solar heating. The radiative coolers are composed of an optical layer reflecting almost the entire solar spectrum capped by an optical layer selectively 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, CNR-SPIN and CNR-Scitec.

My work involved fabricating and characterizing the optical layers for radiative cooling and assembling a vacuum chamber to measure their infrared radiating behaviour. The goal was to mimick outer-space-like conditions using a cold source (liquid nitrogen), and limiting any spurious heat loss (high vacuum, low-heat-conduction setup). I developed a LabVIEW program to acquire the temperature difference between a radiative cooling sample and a reference (dummy) sample, measured with a thermocouple.

The samples placed inside the vacuum chamber consisted of a steel substrate coated with a silver layer, on top of which a polymer layer was pressed. The silver layer was deposited using the e-beam evaporation technique. After deposition, I characterized the samples by spectroscopic ellipsometry.

The polymer layers were prepared at the CNR-Scitec laboratory and subsequently pressed onto the silver-coated substrates. I characterized the different polymers by IR spectroscopic ellipsometry. Among them, polymethylpentene showed one of the highest absorption/emission levels in the spectral range of interest. To further enhance the emissivity of the samples, silica microparticles were dispersed within the polymer matrix. Such samples, when tested in the above-described high-vacuum chamber, showed the largest temperature differences with respect to the dummy samples, as expected.

The second part of the project was to create active Distributed Bragg Reflectors (DBR) meant to act as voltage-tunable layer with variable reflection in the visible range. The DBRs were manufactured by Politecnico di Milano by spin-coater. I learned how to make DBRs and then I characterized some samples by spectroscopic ellipsometry with the aim of improving the reflectance spectrum of the samples.

CONFERENCES AND SCHOOL

- The EUropean POlymer Conference "MacroLight" (EUPOC 2025), May 11 – 15, Bertinoro, Italy.
  Poster presentation: *Toward Voltage-Modulated Passive Daytime Radiative Coolers*
- Networking Event, *Dialoghi tra SCITEC e UNIGE*, February 19, Genova, Italy.
  Poster presentation: *Passive Daytime Radiative Coolers*

PUBBLICATIONS

Published 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,* Advanced Engineering Materials, 2024, 2401157.

Submitted article:

Ermes Peci, Yang Pan, Emma Spotorno, Lorenzo Ramò, Francesca Telesio, Michele Magnozzi, Zygmunt Milosz, Luca Gregoratti, Matteo Amati, Nicolò Petrini, Ilka Kriegel, Dietrich R.T. Zahn, Maurizio Canepa, and Francesco Bisio, *Mechanisms of laser-induced defect healing in transition metal dichalcogenide monolayers*

PhD COURSES

Applied Cryogenics (Dr. Musenich) – exam passed

Teoria Quantistica di Sistemi Elettronici e Fotonici

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.