

Physics Ph.D. Annual Report – Second year

Student: Lorenzo Ramò (XXXVI cycle)

Supervisors: Dr. Francesco Bisio and Prof. Maurizio Canepa

Research activity

During my second year of PhD we fabricated plasmonic nanostructures, with the aim of performing ultrafast pump-probe measurements of the heat dynamics at the nanoscale. The measurements consisted in irradiating the nanostructures with a “pump” laser, and detect the effect of the temperature increase. These samples were analyzed at OptMatLab and at EFSL (Euro Fel Support Lab) of CNR in Rome. At this stage, it was not possible to detect the desired signal because the particular thermo-optical response of the plasmonic structures masked the useful part of the signal. Therefore, we undertook a collaboration with Graphene Labs at Istituto Italiano di Tecnologia in Pisa in order to replace the plasmonic layer used for temperature sensing with a system based on 2D semiconductors. The realization of these new devices was performed and a new session of measurements is planned. A new setup for pump-probe measures with microseconds time resolution was designed and is under construction.

In the meanwhile, also the first plasmonic nanostructures realized via thermal scanning probe lithography on insulating substrates were successfully obtained. The fabrication recipe was calibrated and adapted in order to progressively reduce the size of the achievable nanostructures. Up to now we managed to obtain, in a reliable way, nanostructures about 150 nm in size, capable of supporting resonances in the near infrared regime. The following stage is the realization of nanostructures smaller than 100 nm for visible-range applications. In order to acquire spectra over a wide span of energies from the ultraviolet to infrared wavelengths, an upgrade of the micro-transmittance setup is nearing completion.

Among side projects, a recipe for the synthesis of large-area bidimensional semiconductors on functionalized substrates was effectively tuned in the scope of a collaboration with Ermes Peci (another PhD of the OptMatLab group) and the Group of Functional Nanosystems at Istituto Italiano di Tecnologia in Genova. Preliminary results seem to support the possibility of direct patterning of these bidimensional materials with a laser of suitable wavelength. In the next future new ways of functionalization (e.g. with self-assembled organic layers) will be tested in order to tune the final properties of the bidimensional materials and its performances in direct-patterning processes.

Publications

- M. Ferrera, L. Ramò, D. Convertino, G. Orlandini, S. Pace, I. Milekhin, M. Magnozzi, M. Rahaman, D. R. T. Zahn, C. Coletti, M. Canepa and F. Bisio *Optical Response of CVD-Grown ML-WS₂ Flakes on an Ultra-Dense Au NP Plasmonic Array*, *Chemosensors* **120 (10)**, 2022
- E. Peci, M. Magnozzi, L. Ramò, M. Ferrera, D. Convertino, S. Pace, G. Orlandini, A. Sharma, I. Milekhin, G. Salvan, C. Coletti, D. Zahn, F. Bisio and M. Canepa *Dielectric function of two-dimensional WS₂ in homo- and heterobilayers* (under revision)

Conferences

- Plasmonica 2022 – International school on Plasmonics and Nano-optics (4-7 July 2022, Turin, Italy) and 8th edition of the Workshop on Plasmonics and its Applications (7-8 July 2022, Turin)

Poster presentation: *Optical Response of CVD-Grown ML-WS₂ Flakes on an Ultra-Dense Au NP Plasmonic Array*

- Metamaterials – 16th International congress on artificial materials for novel wave phenomena (12-17 September 2022, Siena, Italy)

Poster presentation: *Optical Response of CVD-Grown ML-WS₂ Flakes on an Ultra-Dense Au NP Plasmonic Array*

Seminars

- Didactical oral presentation “Introduction to thermoplasmonics” (1 hour). Course: Spettroscopie e materiali per la fotonica, Master’s degree level – Laurea Magistrale in Fisica e Laurea Magistrale in Scienza e Ingegneria dei Materiali, Dipartimento di Fisica, Università degli Studi di Genova

Courses and exams

- First on-line School on Synchrotron Radiation “Gilberto Vlaic”: Fundamentals, Methods and Application (from 13/09/2021 to 17/09/2021)

Exam passed on 02/12/20221

- Fisica Computazionale/ Computational Physics (Master course in Physics) – Prof. Riccardo Ferrando and Dr. Davide Bochicchio (attendend during the first PhD year)

Exam passed on 20/12/2021

- Organic materials for photonics (“Scienza e tecnologie dei materiali” Ph.D. course) – Prof. Davide Comoretto

Exam passed on 05/08/2022

Other activities

- First semester didactical tutor for the course “Fisica e laboratorio di misure fisiche” (1th year Biological Sciences) – Prof.ssa Alessandra Pesce (49 hours) project A_SMFN_01