

Annual Report

Student: Marzia Ferrera (XXXIV cycle – 2nd year)

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ACTIVITY

During my second-year PhD studies, my research activity was primarily focused on the fabrication and investigation of the physico-chemical properties of group VI semiconducting transition metal dichalcogenides (TMDs), *i.e.* monolayer tungsten disulphide (ML-WS₂).

At the beginning of 2020, I had the opportunity to perform a training stage within Dr. C. Coletti group at CNI@NEST – Istituto Italiano di Tecnologia (Pisa, Italy), with the aim of synthesizing single-crystalline flakes of ML-WS₂ on sapphire *via* chemical vapour deposition (CVD). The as-fabricated ML-WS₂ underwent several treatments in order to explore the effects on its stability of the temperature and pressure standardly employed during back-end-on-line (BEOL) process, which is typically used for WS₂-based devices integration with Si chips. This study on ML-WS₂ thermal stability supports results of an analogous investigation performed in Genova, that focused on the thermo-optical characterization of polycrystalline ML-WS₂ on sapphire by means of *in situ* spectroscopic ellipsometry under high-vacuum (HV) conditions; this study shed light on the thermal behaviour of excitons in 2D layered semiconductors and on the reversibility of WS₂ optical response after HV annealing from room temperature to 550°C.

In the framework of optimizing this kind of experiments (ellipsometry under HV conditions), I also designed by means of AutoCAD a new portable roll-on/roll-off HV chamber to be fitted between the arms of the spectroscopic ellipsometer M2000 in order to perform real time optical measurements in the temperature range 77-800 K.

Further insights into the optical properties of 2D TMDs were obtained by performing photoluminescence (PL) experiments on WS₂ triangular flakes with micrometer spatial resolution, with the scope of probing the evolution of PL peak over the flakes area. This information was complementary to the investigation at the microscale of the dielectric function of WS₂ via imaging ellipsometry performed thanks to a collaboration between OptMatLab@DiFi and the Laserinstitut Hochschule Mittweida (D).

The results obtained from the characterization of ML-WS₂ together with the expertise in the fields of plasmonics and thermoplasmonics I have been acquiring since my Master's thesis constituted the basis of a preliminary work devoted to the realization and characterization of plasmonic-TMDs heterostructures, which will represent one of the main systems I will address during my third-year research activity.

PUBLICATIONS

- **M. Ferrera**, M. Magnozzi, M. Canepa and F. Bisio, *Thermoplasmonics of Ag nanoparticles in a variable-temperature bath*, The Journal of Physical Chemistry C, **124**, 17204-17210 (2020).
- **M. Ferrera**, G. Della Valle, M. Sygletou, M. Magnozzi, D. Catone, P. O'Keeffe, A. Paladini, F. Toschi, L. Mattera, M. Canepa and F. Bisio, *Thermometric calibration of the ultrafast relaxation dynamics in plasmonic Au nanoparticles*, ACS Photonics, **7**, 959-966 (2020).
- M. Magnozzi, **M. Ferrera**, G. Piccinini, S. Pace, S. Forti, F. Fabbri, C. Coletti, F. Bisio and M. Canepa, *Optical dielectric function of two-dimensional WS₂ on epitaxial graphene*, 2D Materials, **7**, 025024 (2020).
- **M. Ferrera**, M. Magnozzi, F. Bisio and M. Canepa, *Temperature-dependent permittivity of silver and implications for thermoplasmonics*, Physical Review Materials, **3**, 105201 (2019).

Submitted article:

- S. Pace, **M. Ferrera**, D. Convertino, G. Piccinini, M. Magnozzi, N. Mishra, S. Forti, F. Bisio, M. Canepa, F. Fabbri and C. Coletti, *Thermal stability of monolayer WS₂ in BEOL conditions*, Journal of Physics: Materials, Submitted Manuscript.

SCHOOL AND CONFERENCES

- **POM – Photonics Online Meetup 2020**, June 22 and 25, online.
Poster presentation: Thermometric calibration of the ultrafast relaxation dynamics in plasmonic Au nanoparticles.
<https://twitter.com/PhotonicsMeetup>
- **ICFO-MIT SCHOOLS ON THE FRONTIERS OF LIGHT Symposium on “Emergent Phenomena in Moiré Materials” 2020**, July 6–17, online.
Poster presentation: *In situ* optical characterization of low dimensional systems.
<http://frontiers.icfo.eu/2020/07/04/marzia-ferrera/>
- **106° CONGRESSO NAZIONALE SOCIETA' ITALIANA DI FISICA 2020**, September 14–18, online.
Oral communication: Thermometric calibration of the ultrafast relaxation dynamics in plasmonic Au nanoparticles. <https://www.sif.it/attivita/congresso/106>

Workshops and virtual events without contribution:

- **4° Workshop Graphene Flagship EU-Japan on Graphene and related 2D materials**, Scuola Normale Superiore, Pisa, 18-20 November 2019.
- **PlasmONicaLINE**, SIOF – Società Italiana di Ottica e Fotonica, Plasmonica & Nano-Ottica Working group, virtual seminars on “Metasurfaces” and “Sensing”, online, 30 April and 20 May 2020.
- **CARBONILEHAGEN**, online symposium on two-dimensional materials, online, 7 and 14 May 2020.
- **Graphene for Energy Storage Applications**, online, 17 June 2020.

SEMINARS

- **Online oral presentation about Raman and Photoluminescence spectroscopy** (2 hours).
Course: Metodi Ottici e Spettroscopici per lo Studio dei Materiali, 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

- **Gravitational waves – Theoretical and experimental aspects** (Master course)
Exam passed on 29/07/2020
- **Summer School – ICFO-MIT Schools on the Frontiers of Light. Symposium on “Emergent Phenomena in Moiré Materials”**, online 6-17 July 2020.
Exam scheduled for October 2020

Other courses:

- **Corso di Base di Tecnologie del vuoto**, 16 hours, Genova, 11-12 November 2019
Exam passed on 12/11/2019
- **Corso di Tecnologie di Deposizione PVD e CVD e Caratterizzazione SEM e XPS**, 16 hours, Genova, 13-14 November 2019
Exam passed on 14/11/2019

OTHER ACTIVITIES

- 7th January 2020 – 20th March 2020. **Tutoring activity** for high school students.
Project: “Attività di supporto all’orientamento inerenti la Scienza dei Materiali, nell’ambito del Piano Nazionale Lauree Scientifiche 2018-2019” – incarico di lavoro autonomo di natura occasionale.