Annual Report

Student: Marzia Ferrera (XXXIV cycle)

Supervisors: Dr. Francesco Bisio and Prof. Maurizio Canepa

ACTIVITY

The central topic of my first-year Ph.D. research activity has been the investigation of nanomaterials. I have addressed two classes of nanomaterials, namely plasmonic systems (*i.e.* ensembles of nanosized metallic particles), and the so-called two-dimensional layered materials. These atomic-thick materials can be stacked in various ways giving birth to peculiar properties which could be exploited to fabricate new devices. Within the project STRATOS, in collaboration with DIFI, INFN, IIT and CNR-SPIN, I started to study materials whose properties are reasonably well-known, with a particular attention to transition metal dichalcogenides. For the investigations, I employed several spectroscopic (spectroscopic ellipsometry, Raman spectroscopy, X-ray photoemission spectroscopy) and microscopic (atomic force microscopy) techniques.
In detail, the topics that have been addressed during the past year are:

- thermo-optical response of plasmonic nanosystems by means of *in-situ* spectroscopic ellipsometry and transmittance spectroscopy,
    - effect of temperature and state of oxidation on the optical properties of ultra-dense arrays of silver nanoparticles.
    - investigation of the temperature-dependent permittivity of silver.
- 2D heterostack made of a monolayer of tungsten disulfide (WS_2) grown on the substrate SiC (0001)|QFSMLG (silicon carbide (0001)| quasi-free standing monolayer graphene). Spectroscopic ellipsometry allowed to obtain accurate optical properties of layered materials. This investigation is a good starting point for the study of increasingly complex heterostacks. The possibility to do *in-situ* thermo-optical characterization will address my future work towards the determination of the real-time modification of the dielectric function of two-dimensional materials as a consequence of a temperature increase. This investigation will be complementary to a previous study developed this year in collaboration with IIT related to the high temperature instability of monolayer WS_2 (*ex-situ* characterization).

A future development is represented by the use of plasmonic arrays of metallic nanoparticles as a substrate for two-dimensional materials in order to realize hybrid nanostructures with new outstanding properties.

Moreover, from 16th October 2019 to 1st November 2019 I took part to an experimental session at the open access facility NFFA in Trieste (beamline SPRINT) with the proposal “Time-resolved investigations of Plasmon-mediated hot electron injection from Au NPs in Al-doped ZnO films” written by Dr. Maria Sygletou.

PUBLICATIONS

Published articles:

- M. Magnozzi, M. Ferrera, L. Mattera, M. Canepa and F. Bisio, *Plasmonics of Au nanoparticles in a hot thermodynamic bath*, Nanoscale, **11**, 1140-1146 (2019).

- M. Magnozzi, M. Ferrera, M. Canepa and F. Bisio, *Monitoring the solid-state dewetting of densely packed arrays of Au nanoparticles* (Conference Paper), Journal of Physics: Conference Series, **1226** (2019).

Submitted article:

- M. Ferrera, M. Magnozzi, F. Bisio and M. Canepa, *Temperature-dependent permittivity of silver and implications for thermoplasmonics*, Physical Review Materials, Submitted Manuscript.

In preparation articles:

- M. Magnozzi, M. Ferrera, G. Piccinini, S. Pace, S. Forti, F. Fabbri, C. Coletti, F. Bisio and M. Canepa, *Optical dielectric function of WS_2 on epitaxial graphene*, In preparation.

- S. Pace, M. Ferrera, G. Piccinini, N. Mishra, M. Magnozzi, S. Forti, F. Bisio, M. Canepa, F. Fabbri and C. Coletti, *High temperature instability of monolayer WS_2 grown by low pressure chemical vapor deposition*, In preparation.

CONFERENCES

- **ICSE 8 BARCELONA 2019,** 8-th International Conference on Spectroscopic Ellipsometry, May 26th – 31st, 2019, Barcelona, Spain.
  Poster presentation: Temperature-dependent study of localized surface plasmon resonance in 2D arrays of silver nanoparticles.
  https://congresses.icmab.es/icse8/images/programme/icse8program-web-3.pdf

- **IMN 2019,** second International Meeting on Nanoalloys, June 4th – 7th, 2019, Genova, Italy.
  Poster presentation: Thermo-optical response of plasmonic arrays of metallic nanoalloys.
  http://nanoalloys-irn.cnrs.fr/wp-content/uploads/2019/06/abstract_booklet.pdf

- **PLASMONICA 2019,** International workshop on Plasmonics, June 19th – 21st, 2019, Naples, Italy.
  Oral presentation: Plasmonics of Au nanoparticles in a variable-temperature thermodynamic bath.
  http://www.plasmonica.it/2019/program.html

- **GRAPHENE 2019,** 9th edition of the largest European Conference & Exhibition in Graphene and 2D Materials, June 25th – 28th, Rome, Italy**.**
  Poster presentation: Dielectric function of monolayer WS_2: a spectroscopic ellipsometry investigation.
  http://www.grapheneconf.com/Files/Graphene2019_AbstractsBook.pdf

The following activities refer to the period between the Ph.D. entrance examination and the beginning of Ph.D. (1st November 2019).

- **PLASMONICA 2018,** International workshop on Plasmonics, July 4th – 6th, 2019, Florence, Italy.
  Poster presentation: Temperature dependent optical constants of noble metals Au and Ag.
  http://www.plasmonica.it/2018/downloads/Plasmonica2018_Book_of_Abstracts_2018-07-30.pdf

- **DCMS MATERIALS 4.0 SUMMER SCHOOL 2018,** Deep Materials: Perspectives on data-driven materials research, September 10th – 14th, 2018, TU Dresden, Germany.
  Poster presentation: Temperature dependent optical constants of noble metals Au and Ag.
  http://dcms.tu-dresden.de/wp-content/uploads/2018/09/materials40_18_book_of_abstracts.pdf

- **Materials.it 2018,** October 22nd – 26h, 2018, Bologna, Italy.
  Oral presentation: Effective dielectric modelling of hot gold nanoparticles.
  https://eventi.cnism.it/sites/default/files/materials2018/Materials.it%202018%20book%20of%20abstract.pdf#overlay-context=materials2018

COURSES AND EXAMS

- **Electronics and data acquisition** (Ph.D. course)
  Exam passed on 03/06/2019

- **Spectroscopic and microscopic analysis of surfaces and interfaces** (Ph.D. course)
  Exam passed on 22/07/2019

- **Metodi di simulazione applicati alla fisica** (Master course)
  Exam passed on 11/09/2019

OTHER ACTIVITIES

- **Tutor** for high school students at the ***Stage@DiFi 2019*** event
  28th January 2019-7th February 2019
  In collaboration with Dr. M. Magnozzi, Dr. F. Bisio and Prof. M. Canepa, I presented "Two-dimensional materials: graphene": fabrication of graphene flakes (mechanical exfoliation) and spectroscopic characterization (Raman spectroscopy).

- **Didactic Tutor**
  Project: *attività di supporto, studio e consulenza (gestione di materiale per un laboratorio on-line nell'ambito del progetto* ***"Riduzione del tasso di abbandono del PLS in Matematica 2015-2018"****)* - incarico di lavoro autonomo di natura occasionale
  40 hours (15th March 2019- 30th June 2019)

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- **Didactic Tutor**
  Project: A_SMFN_07
  Incarico di collaborazione ad attività di espletamento di servizi di tutorato – anno 2017/2018 (bando di concorso, D.R. n. 1889 del 09/05/2018)
  20 hours (18th September 2018- 28th November 2018)