PhD in PHYSICS

Research Title: Enhanced Raman spectroscopy for the characterization of resistive switching in metal-oxide nanostructures.

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<tr>
<td>Supervisor</td>
<td>Prof. Fabrizio Giorgis, Prof. Carlo Ricciardi</td>
</tr>
<tr>
<td>Contact</td>
<td><a href="mailto:fabrizio.giorgis@polito.it">fabrizio.giorgis@polito.it</a>, <a href="mailto:carlo.ricciardi@polito.it">carlo.ricciardi@polito.it</a></td>
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The Department of Applied Science and Technology (DISAT) is looking for a PhD candidate in the domain of enhanced vibrational spectroscopy and spectroscopic imaging applied to dielectric nanostructures such as ZnO nanowires. The proposed PhD activity is supported by 3-year funding from the DISAT Excellence Research Project, which generally aims at expanding the department capabilities in optical, electronic and probe microscopy.

The PhD project is focused on the application and optimization of an experimental set-up consisting in a micro-Raman spectrophotometer coupled to a STM/AFM probe microscope (Scanning Tunneling- & Atomic Force-Microscopy), able to perform Raman and TERS (Tip-Enhanced Raman Scattering) imaging. Such apparatus takes advantage of plasmonic nanotips (Au/Ag) yielding huge electromagnetic enhancements under suitable optical excitation. Such phenomenon can be exploited for obtaining the vibrational spectra of an analyte in physical contact (or within a nanometric local distance) with respect to the nano-tip showing: i) a noticeable enhancement of Raman scattering, ii) the possibility to conduct spectroscopic mapping with a spatial resolution well beyond the diffraction limit, due to the electromagnetic near-field localized at the nano-probe apex. This technique will be applied for the composition analysis.
of nanostructured metal-oxides, focusing on the detection of oxygen vacancies. The study will be aimed to the process of “resistive switching” (consisting in reversible variation of electric resistance under strong electrical fields), which can be correlated to the local variation of the atomic composition/microstructure concerning the nanostructured material. Such local heterogeneity of the elemental composition is linked to the vacancies migration induced by an external electrical stimulus. As a consequence, nanoionic transport processes provoke a local variation of the stoichiometry and of the electrical conductivity. Nanoionics and resistive switching are investigated as the physical mechanisms underlying memristors, a new class of nanodevices that are predicted to be the next revolution in brain-inspired computing. In this framework, Raman/TERS imaging/spectroscopy will be applied for monitoring nano-structural heterogeneities correlated to the above mentioned ionic transport in metal-oxide nanostructures.

### Objectives

The PhD candidate will carry on several activities, whose objectives are described below.

- Optimization of a TERS set-up aimed to perform enhanced Raman imaging at high spatial resolution.
- Development of plasmonic nanotips by physical sputtering growth performed on AFM nanoprobes.
- Synthesis of metal-oxide nanowires (i.e. ZnO), setting up a platform able to conduct enhanced Raman imaging with a suitable AFM and/or STM feedback.
- Data analysis concerning the spectroscopic data, to be correlated with the electrical properties of the dielectric nanowires.

### Skills and competencies for the development of the activity

The candidates should hold a Master Degree in Physics, Physics Engineering, Electronics, Nanotechnology or related disciplines. The following competencies/skills, which deal with an experimental activity, are required:

- knowledge of fundamental optical spectroscopy and electronics
- knowledge of basic nanofabrication technologies
- ability to work in team

A good knowledge of written and spoken English is a pre-requisite.