



# PhD in SCIENZE E TECNOLOGIE ENERGETICHE E NUCLEARI / ENERGY AND NUCLEAR SCIENCE AND TECHNOLOGY - 40th cycle

THEMATIC Research Field: STUDY OF NOVEL CARBON NANOMATERIALS ABSED ON LINEAR SP-CARBON ATOMIC WIRES

**Monthly net income of PhDscholarship (max 36 months)**

**€ 1500.0**

In case of a change of the welfare rates during the three-year period, the amount could be modified.

## Context of the research activity

**Motivation and objectives of the research in this field**

In the last 30 years, the discovery of fullerenes, nanotubes, and graphene has nurtured the interest in linear carbon structures with  $sp$ -hybridization in the form of carbon atomic wires. Carbon atomic wires represent the ultimate 1-D carbon system (i.e. carbyne) and are interesting for fundamental and applied science. Recent theoretical calculations have outlined outstanding mechanical, thermal, and electronic properties which can be tuned by controlling the wire length and the terminating functional group. The design and control of the wire structure open the way to building materials with tunable properties, which is at present a largely unexplored topic. The research activity is focused on the experimental fabrication and investigation of  $sp$ -carbon atomic wires (linear  $sp$ -hybridized carbon nanostructures) and on the development of wire-based materials. The characterization is done mainly by vibrational spectroscopy (Raman, SERS). The assessment of the functional properties as well as the understanding of the structure-property relationship is a fundamental issue. Focus of this PhD program will be on the development of novel nanostructured materials based on  $sp$ -carbon atomic wires (e.g. carbyne, polyynes, cumulene) and nanostructured thin films from fundamental science to applications with particular attention to:

- synthesis of carbon atomic wires with controlled



	<p>structure and investigation of morphology, structure, vibrational and electronic properties.</p> <ul style="list-style-type: none"> <li>- study of fundamental aspects on structure-property relationship</li> <li>- exploration of potential applications</li> </ul> <p>See: <a href="http://www.explore.polimi.it/">http://www.explore.polimi.it/</a></p>
<p><b>Methods and techniques that will be developed and used to carry out the research</b></p>	<p>The research activity is based on experimental work and data analysis. Carbon nanostructures will be fabricated by physical methods such as pulsed laser ablation in liquid (PLAL) and/or submerged arc discharge in liquids (SADL) available at Nanolab at the Department of Energy. Characterization techniques will be used to study vibrational optical and electronic properties by UV-vis absorption, Raman spectroscopy and surface enhanced Raman spectroscopy (SERS) also in situ or in operando, available at NanoLab. Data analysis will be performed by simple mathematical tools. Study of published literature will be also part of the work. Methods will be also tailorly set-up for the production of nanocomposites 0-D (nanoparticles), 1-D (nanofibres) and 2-D (thin films or molecular layers) merging competences in physics, chemistry and materials engineering in a multidisciplinary approach. The optimization of the nanocomposite structure and production requires characterization at different scales: 1) the material morphology by electron and scanning probe microscopies (SEM/STEM, SPM); 2) the molecular structure through vibrational spectroscopies (e.g. Raman/SERS); 3) the matrix/material intermolecular interactions.</p>
<p><b>Educational objectives</b></p>	<p>Education of people to be launched in the world of research and technology in the field of physics and engineering of materials, able to manage interdisciplinary issues, perform and interpret complex experiments and produce new equipment. In particular, the PhD student will be trained both in nanomaterial synthesis and advanced characterization, by a group with long standing experience in the field and they will take advantage of state-of-the-art laboratories.</p>



<b>Job opportunities</b>	Private and public R. &D. Highly qualified positions in a wide range of industries related with production, development and use of materials.
<b>Composition of the research group</b>	3 Full Professors 5 Associated Professors 1 Assistant Professors 10 PhD Students
<b>Name of the research directors</b>	C.S. Casari

#### Contacts

Carlo. S. Casari  
 Email: carlo.casari@polimi.it  
 Ph: +39-022399-6331

<http://www.nanolab.polimi.it>

List of 5 Universities, Companies, Agencies and/or National or International Institutions that are cooperating in the research

1. Humboldt University Berlin (Germany)
2. Wroclaw University (Poland)
3. University of Alberta, Edmonton (Canada)
4. Sun Yat-sen University (China)
5. ELETTRA Synchrotron light source (Italy)

#### Additional support - Financial aid per PhD student per year (gross amount)

<b>Housing - Foreign Students</b>	--
<b>Housing - Out-of-town residents (more than 80Km out of Milano)</b>	--

#### Scholarship Increase for a period abroad

<b>Amount monthly</b>	750.0 €
<b>By number of months</b>	6

**Additional information: educational activity, teaching assistantship, computer availability, desk availability, any other information**

**Educational activities:** Financial aid per PhD student is available for purchase of study books and material, funding for participation in courses, summer schools, workshops and conferences, instrumentations and computer, etc. The amount is about 6114 euro.

**Teaching assistantship:** Availability of funding in recognition of supporting teaching activities by



the PhD student. There are various forms of financial aid for activities of support to the teaching practice. The PhD student is encouraged to take part in these activities, within the limits allowed by the regulations.

*Desk availability:* individual use.