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Nanotechnologies and new materials

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Due to its outstanding electronic, optical, morphological and mechanical properties graphene, a single layer of carbon atoms, can be considered a cutting edge material that is opening up new horizons for the research and development of stable, truly 2D material systems. These shall be intended as materials that do not need to be supported by a substrate to exist and therefore can be isolated as free-standing one atom thick layers. Due to confinement of electrons and to the lack of strong interlayer interactions they usually exhibit optical and electronic properties different from their analogous 3D systems. It is possible to control their transport properties and modify their electronic structure through chemical functionalization. Moreover their mechanical flexibility can be exploited for the integration onto inexpensive platforms.
Graphene has rapidly established itself as a building block for optoelectronic applications in various photodetection platforms, which exploit the lack of a bandgap, the high carrier mobility, the small heat capacitance and resistance and the weak electron-phonon coupling in regimes spanning from UV to the terahertz frequency range. Besides graphene, other types of two-dimensional nanomaterials, such as transition metal dichalcogenides, are attracting the scientific and technological attention due to the inherent functional flexibility of the 2D morphology, which offers size dependent anisotropic properties and opens unprecedented opportunities for the development of atomically thin detectors.
In this lecture, the first part will be dedicated to an overview on graphene and other emerging 2D materials, focusing on their electronic and optical properties relevant for the applications in detectors. Then several detectors architectures based on 2D materials and hybrid systems, made of the combination of different 2D crystals, will be presented to outline the state-of-the-art of the research in this field.

Primary author: Dr LARCIPRETE, Rosanna (CNR-ISC/LNF-INFN)

Presenter: Dr LARCIPRETE, Rosanna (CNR-ISC/LNF-INFN)