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CVD processes for growth and shaping of diamond films: new prospectives in nanotechnology and optical applications

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Abstract

Diamond is found in a very wide field of applications from thermal management to mechanical applications, from quantum technologies to optics. For many of these fields of study, a controlled shaping of single-crystal and polycrystalline diamond to the nanoscale is crucial. Using CVD processes it is possible to grow polycrystalline diamond film varying thickness, morphology and surface functionalization. Film properties and shaping can be modified both during or post synthesis. In particular in this talk it will be illustrated some examples of nanostructures obtained starting from diamond films by H-etching processes with a custom-made dual-mode MW-RF plasma reactor. The morphology and structure of nanosized layers have been investigated by FE-SEM, micro-Raman and RHEED. Field Emission and Secondary Electron Emission measurements have also been carried out. Starting from different kind of crystalline films, we obtained nanowires, nanorods, nanocones and nanowhiskers. The high aspect ratio of such elongated structures is responsible for the high local field enhancement effect, and the arrays of needle-like diamond behave as templates for an effective electron emitter. An increasing interest is also arising for the use of such nanostructure in the field of bio-medical applications, as attractive scaffolds for tissue growth and for selective attachment of targeting groups, and for bio-analytical applications.

Diamond interest for optical application is related to the possibility of the formation of fluorescent defects in the diamond lattice, called color centers. These centers display remarkably optical properties as single photon sources and have fluorescence energy range suitable for biological applications. Ion implantation is up to now the most used technique for the formation of color centers, but it does not allow a very high yield of doping, due to the deterioration of the diamond lattice. We use CVD processes to drive the inclusion of color centers during synthesis of diamond films. The CVD process guarantees the formation of good crystalline quality diamonds which represents the basic requirement to enhance the optical properties of the color centers. Two methods to control insertion and position of color centers will be presented. The first method utilizes lithographed SiO_2-NbN substrates and brings to the growth of diamond film with a very intense emission of the Si color center in correspondence of the diamond grown on the SiO_2 compared to the NbN. The second method, supported by a thermodynamic model, consist in a substrate treatment with nickel nanoparticles to obtain unimaginable highly brilliant isolated single crystals or ultra-bright polycrystalline diamond films as compared to the usual CVD or irradiation methods.

The speaker

Stefano Gay received the Laurea *cum laude* in 2011 in Industrial Nanotechnology Engineering from the University of Rome “La Sapienza”, with the thesis entitled “Technology, study and development for the realization of nano/micro porous structures”. He is now a PhD student in Chemical Science at University of Rome “Tor Vergata”. His research is focused on the synthesis methodologies, chemical-physical treatments, and characterization of carbon-based nanocrystalline materials, ranging from diamond films, carbon nanotubes to nanographites for applications as electron sources and optoelectronic systems. He is co-author of 4 papers published on internationally peer-reviewed journals and has participated in several international conferences.