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DADES DE L'EMPRESA I DE L'ENTORN ACADÈMIC

Títol del projecte
Optimization of RF plasma sources for optical surface cleaning & graphene/nanosystem thin film deposition

Empresa
CELLS

Responsable de l'empresa
Eric Pellegrin

Universitat
Universitat Autònoma de Barcelona

Director/a de tesi
Javier Rodríguez Viejo

Treballador/a de l'empresa i doctorand/a
Harol Moreno Fernández

BREU DESCRIPCIÓ DEL PROJECTE DE RECERCA

INDUSTRIAL PhD CELLS-ALBA

The program of the PhD thesis proposed by CELLS-ALBA is based on low-pressure RF plasma technology as well as the pertinent plasma sources and consists of an applied as well as a scientific part. The former applied part is aimed at the further technical development of a RF plasma source for the cleaning of optical precision surfaces - especially of large size optical components - in the field of synchrotron optics as well as next generation Extreme Ultraviolet (EUV) semiconductor lithography. The latter scientific part deals with R&D activities centered on the use of the same type of RF plasma source for the epitaxial thin film deposition of graphene (mono)layers and chemically modified related carbon-based nanosystems. It is foreseen to have Eric Pellegrin (ALBA) and Javier Rodriguez Viejo (UAB) as thesis co-directors.

PROJECT DESCRIPTION

In the last decades, plasma technology has generated an ever-increasing interest/use as a surface conditioning/modification tool for applied as well as fundamental sciences, ranging from the surface hardening of stainless steel to human skin disinfection in medical applications.

Here, we would like to propose two projects that - although being sufficiently close to each other from the plasma source point of view for being jointly enclosed in the present project proposal - cover fields a diverse as the (top-down) cleaning of optical precision surfaces from x-ray beam induced carbon contaminations and, at the same time, the (bottom-up) controlled deposition of

epitaxial graphene layers as well as related carbon-based nanosystems such as carbon nanotubes, etc. including their plasma-induced chemical modification. As an industrial benefit, a successful completion of either one or both proposed projects would offer an excellent possibility for a commercialization of the plasma sources in the two corresponding application fields.

Applied Part: Although the graphitic carbon contamination of synchrotron beamline optics has been an obvious problem for several decades, the basic mechanisms underlying the contamination process as well as the cleaning/remediation strategies are not understood and the corresponding cleaning procedures are still under development. In a parallel manner, the same type of problem is prominent in the field of next-generation EUV lithography, where the operation of open-type plasma-driven light sources results into the contamination of costly EUV multilayer mirrors in semiconductor lithography machines. During the last years, CELLS has undertaken an analysis of remediation strategies - all based on in-situ low-pressure RF plasma cleaning approaches - including a quantitative determination of the optimum process parameters and their influence on the chemistry as well as the morphology of optical test surfaces [1]. As an extension to the work done so far, we propose to perform studies on:
- The development of an end point detection scheme of the cleaning process using in-situ ellipsometry (incl. removable ex-situ instrumentation) [2] in order to avoid an undue "overcleaning" and thus a damage of the optical surfaces involved.
- An in-depth characterization of the plasma kinetics via Faraday cup measurements in order to achieve a better understanding of the plasma physics involved and thus a better control of the kinetic effects during the cleaning process.
- An upscaling of the plasma source size and RF power in order to cope with the large size mirror systems typically used at synchrotron radiation sources as well as in EUV steppers.
- Cleaning of different carbon allotropes (i.e., sp, sp^2, and sp^3 as well as their mixtures) in order to simulate different types of carbon contaminations.

Scientific Part: The recent advent of graphene as a monolayer material with outstanding mechanical, chemical, and electrical properties has generated a large interest in the various thin film graphene deposition techniques at hand. Traditional techniques encompass exfoliation of HOPG bulk and subsequent foil transfer, heat-induced C depletion of SiC(0001) surfaces, as well as chemical vapor deposition (CVD) onto metal surfaces using hydrocarbon gases such as methane. During the last years, CELLS [3] as well as other research groups could establish remote plasma-enhanced CVD (rPECVD) as an alternative thin film deposition technique for nanocrystalline graphene, offering technical advantages such as the decoupling of the hydrocarbon gas dissociation process from the sample thin film deposition and thus resulting into deposition processes at lower substrate temperatures. As a continuation of this endeavor, we propose to tackle the deposition of epitaxial graphene (mono)layers on crystalline substrate materials using rPECVD as well as to take the first steps towards the synthesis of other carbon nanomaterials such as, e.g., multi- or single-walled carbon nanotubes. Due to the inherent chemical flexibility of PECVD via the plasma feedstock gases being used for the deposition process, we also plan to synthesize chemically modified species such as graphene oxide, nitrogen-doped graphene, and reduced graphene oxide via corresponding modifications of the plasma chemistry.