Surface and Material Science Laboratory

Istituto Nazionale di Fisica Nucleare
Divisione Ricerca: DAFNEL

The laboratory makes accessible a series of state-of-the-art instruments to study surface physics. It is mainly oriented to research in material science for R&D in Accelerator physics. However, the available techniques can be used in fields with similar research themes but completely different objectives: R&D in Aerospace Engineering, Plasma Physics, etc. Possible thesis, which can be successfully conducted in our laboratories, are listed below.

Contacts: [1] Roberto.Cimino@lnf.infn.it [2] Rosanna.Larciprete@lnf.infn.it
[3] Marco.Angelucci@lnf.infn.it [4] Luisa.Spallino@lnf.infn.it

Study of Secondary Electrons Emission from Surfaces for Aerospace Applications [1]

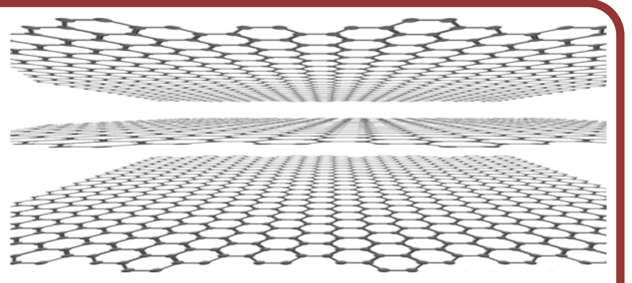
This thesis work will use the laboratory facilities to study Spacecraft charging. This is one of the main causes of anomalies and failures of a mission because of the plasma environment that envelops the spacecraft. In fact, electrons, photons and protons bombard the different materials in orbit. Since no electric ground is available in space, the formation of a high electrostatic voltage may occur. This phenomenon, called "Spacecraft charging" can cause dangerous discharges between differently charged materials. An important factor in spacecraft charging is the yield of the secondary electrons (SEY) from different surfaces exposed to the primary radiation typical of the spatial environment. The thesis aims to study different materials and material coatings and optimize them to mitigate this effect.

Search of passivating coatings for ultimate performances Vacuum chambers [1] [2]

This thesis work will use the laboratory facilities to study surface preparation/modification apt to produce a vacuum chamber with minimal desorption properties, especially during photon or electron irradiation. The laboratory is equipped with all the technologies and instruments to study thermal, electron and photon stimulated desorption, and some facilities to produce specially designed surfaces and coatings.

Surface morphology modifications, thin film Carbon films, up to Graphene-like coatings, and NEG coatings will be studied to define, at least in principle the way to produce as inert as possible surfaces for Ultra high vacuum applications.

Thickness dependence of SEY in thin film coated surfaces [1] [2]



The Secondary Electron Yield, i.e. the number of electrons produced per incident electron of a given energy, is an ubiquitous problem in many fields of research, spanning from Accelerator to Spacecraft R&D. It is well known that two materials may have different values of SEY, determining their potentialities to be used in many applications. Moreover, the intrinsic SEY can be strongly modified by different atomic and molecular layers on the surface.

What is not yet been studied is the thickness dependence of SEY and which is the minimum coverage of the overlayer that will grant the desired SEY.

The thesis aims to address this issue by using all the surface science spectroscopies available in the laboratory, also growing "in situ" thin Carbon films (known to have low SEY) onto different metal substrates (with higher SEY) to identify the thickness at which the SEY is dominated by the overlayer.

Hydrogen storage in graphene [2][1]

The control of hydrogen adsorption on graphene (Gr) and the thermodynamic stability of hydrogenated Gr are fundamental topics in view of new potentialities and possible future developments in the field of hydrogen storage. Particularly relevant is the hydrogenation of supported Gr, due to the importance to determine the thermal stability of chemisorbed hydrogen and the real storage capacity, in the presence of a weakly or strongly interacting substrate. Moreover hydrogenation of sponge-like 3D Gr offers the intriguing perspective to reach gravimetric densities comparable to that of graphane, the material predicted to consist of fully hydrogenated free-standing Gr.

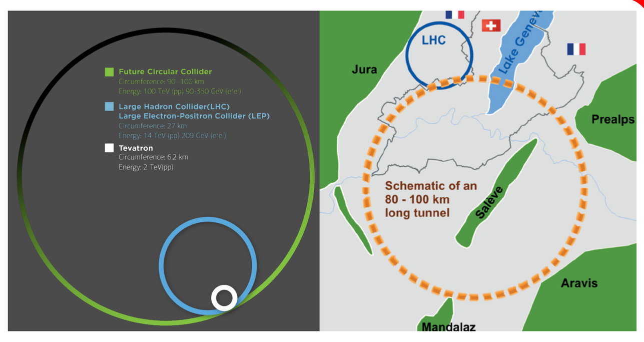
This thesis will investigate the interaction of H atoms with Gr epitaxial on different metal substrates and with free-standing nanostructured Gr by means of photoelectron and Raman spectroscopies and thermal programmed desorption.

Synchrotron radiation desorption studies of candidates materials to be used for the High Luminosity upgrade for the LHC at CERN [1][3]

This thesis work will be done in close collaboration with CERN and is finalised to the optimization of the LHC upgrade. New vacuum chambers with integrated tungsten-shielded beam-screen (BS) will have to be installed. A thorough characterization of the surface properties of the BS needs to be done. In particular for the co-laminated copper with different surface treatment for electron cloud mitigation, like amorphous-carbon (a-C) thin film and laser-structured surfaces, with potential applications also for the Future Circular Collider (FCC) design study.

In addition, recent studies have pointed out that the heat load transferred by electron clouds to the LHC arcs' cryogenic systems will remain a subject of concern also in the HL-LHC era, when the number of SR photons will double. A better understanding of the role of synchrotron radiation in the electron cloud built-up process is essential.

Vacuum stability studies at cryogenic temperature of candidates materials to be used for the FCC-hh project at CERN [1][4]



This thesis work will be done in close collaboration with CERN, and is finalised to the study of potential solutions for the vacuum chamber systems for the Future Circular Collider (FCC-hh), the new highest energy and intensity accelerator proposed to be built at CERN. In the framework of the European EuroCirCol collaboration, different groups are producing design studies and prototypes for the beam-screen of FCC-hh. Its design, operating temperature and structure must fulfil a number of different technical requirements. Among such requirements, vacuum stability at cryogenic temperatures needs to be studied in details. The objective of this thesis work is to test and validate the various material surfaces proposed to be used. The candidate will access two dedicated UHV systems to study gas adsorption/desorption processes at cryogenic temperature.

What happened to interstellar ices and how we can investigate it [1]

Dense protostellar molecular clouds, out of which stars and planetary systems come from, are expected to have very low temperature. This condition supports the formation on the surfaces of thick ices of basic and simple molecules as H_2, H_2O, CO, CO_2, NH_3. Such ice clusters will be exposed to all sorts of radiations, going from photons, cosmic rays to electrons. The interaction and the evolution under irradiation is one of the hottest topics in the research for potentially prebiotic species and formation of complex organic matter, possibly incorporated into planetesimals at the origin of the solar system. In this thesis work we will analyse some electron induced energetic and thermal processes on these ices. The results will be analysed in view of their possible contribution to a better understanding on what could have been happened in early universe during irradiation of protostellar molecular clouds.