# Nuclear radioactive techniques applied to study add-atoms on surfaces

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In the last two decades, the investigation of nanostructures and thin film materials have assumed a prominent role in physics and materials engineering, dedicated to the miniaturization of devices in a multitude of applications. Electrical and magnetic properties and molecular functionalization at the nanoscale materials strongly depend on surface and interface phenomena. These are different from bulk properties, thus requiring new physical models aiming the understanding and control of surface, interface and surface-functionalization properties.

ASPIC (*Apparatus for Surface Physics and Interfaces at CERN*) is an interconnected set of sophisticated equipment that allows the study of surfaces, thin films and interfaces in an UHV environment ($2x10^{-9}$Pa), using the Perturbed Angular Correlation (PAC) technique and a multiple of in-situ surface characterization techniques. This experiment is located at the ISOLDE facility and consists of two main chambers: the first chamber contains the system for collecting the isotopes and is directly connected to the beam line of radioactive ions (mass separator) – that subsequently allows the transfer of radioactivity to an interconnected second UHV chamber where the sample is mounted. The sample's surface can be cleaned by erosion (Ar ions) and heated or cooled (77K to 1273K) in situ. Two systems MBE (Molecular Beam Epitaxy) allow atomic layers to be grown on the surface with additional monitoring by diffraction LEED and Auger electrons. The radioactive ions are then deposited by evaporation from an ion collector foil (of Ta). The use of ASPIC will provide the study and understanding of the interactions, binding energies, configurations and fields at surfaces and interfaces of single atoms by using "ad-atom" probes in materials such as ultra-thin multiferroic films, graphene and functionalized nanoparticles.

By using the PAC technique measuring at ad-atoms the magnetic and electric properties are studied at a local atomic scale, without interference from the measurement system. Additional studies using tunneling microscopy may also be performed when possible integration of this equipment in the experimental system. The *in situ* characterization of samples will reveal the nanoscopic behavior and its correlation to macroscopic phenomenology.

We will present a brief description of ASPIC, its activation and intended upgrades, and future applications. First PAC results are presented that were obtained during a preliminary study of $^{199m}$Hg/$^{199}$Hg add-atoms delivered under water solution to monolayers of graphene.