<u>Title:</u> **Antimultipacting thin films for particle accelerators**

<u>Abstract:</u> The phenomenon of multipactor (or multipacting) is a critical issue that can occur in particle accelerators, particularly in superconducting radio frequency (SRF) accelerating cavities and beamlines. It happens when free electrons present in the cavity are accelerated by the RF electromagnetic field, collide with the cavity walls, and cause the emission of secondary electrons. This process can repeat, amplifying the number of electrons and creating an electron discharge. The multipactor effect disturbs the RF field in the cavity, thus reducing its energy efficiency and leading to a degradation of overall performance. Additionally, it can cause local overheating, compromise superconductivity, and induce a premature limitation of the accelerator field gradient. In beamlines, this phenomenon leads to the formation of electron clouds, as seen in the LHC, limiting machine performance by causing pressure increases, heat deposition on walls, and an increase in proton beam emittance.

The multipacting phenomenon is linked to the surface properties of materials, particularly the Secondary Electron Yield (SEY), which is the ratio between the number of secondary electrons and the number of primary incident electrons. To mitigate the multipacting effect, it is necessary for the SEY to be less than one, which can be achieved through material approaches, such as coating the walls of accelerator components. One of the materials considered anti-multipacting is titanium nitride (TiN) or titanium carbide (TiC) because their SEY is inherently low. To improve the properties of these thin films, I focused on the fabrication, characterization, and study of TiN_xC_y-based coatings and NbN/TiN multilayers. I investigated the intrinsic properties of these layers while eliminating roughness effects, which are known to reduce SEY, by depositing them on silicon substrates. The preferred deposition methods were PVD (Physical Vapor Deposition), which allows for the rapid design of model coatings, and ALD (Atomic Layer Deposition), which enables the production of conformal coatings suitable for three-dimensional structures. We present the results obtained based on the nature of the coating: (i) first, the structure (using X-ray diffraction measurements), morphology, and microstructure of the developed layers (using scanning electron microscopy) as well as layer thickness (using X-ray reflectometry) were characterized; (ii) the physical properties (such as electrical properties through 4-point measurements) were measured, and physico-chemical characterizations (layer composition determined by XPS analysis) were conducted; (iii) the secondary electron emission yields of the deposited layers were measured in both unconditioned and fully conditioned states after electron bombardment. Finally, thin TiN layers were deposited on copper cylinders to characterize the multipactor effect in a dedicated setup.

The role of carbon in secondary electron emission was particularly studied. ALD deposition protocols were established to improve the quality of the deposited layers. Finally, the results highlighted the positive effects of a multilayer structure on reducing SEY, opening up interesting and innovative prospects for anti-multipacting coatings in SRF cavities.