ID de Contribution: **64** Type: **Invited presentation**

Design of innovative diamond detectors for beam monitoring in highly radiative environment for applications in nuclear and medical physics.

mardi 26 septembre 2023 18:00 (25 minutes)

New accelerators are being developed, either for medical applications (X-ray radiotherapy, hadrontherapy, radiotherapy by synchrotron radiation and "flash" therapies), or for nuclear physics. These developments create the need for very precise beam monitoring with fast counting in a highly radiative environment. An important issue is the adaptation to the temporal beam structures, which vary greatly depending on the type of accelerators (cyclotrons, synchro-cyclotrons or synchrotrons), in terms of duty cycle or peak intensity. A recent tendency to increase the intensity of the beams, for example in a clinical setting, for flash therapy, poses new challenges for the detection of secondary radiation (adapting the counting capacity of the detectors, electronics and data acquisition). The intrinsic qualities of diamond (fast timing, low leakage current, excellent signal-to-noise ratio, radiation hardness, equivalence to human tissue) make this semiconductor a perfect candidate to meet the monitoring requirements of such accelerators and the detection of particles.
The objectives of our multidisciplinary projects are the development of innovative diamond detectors for beam monitoring based either on single or poly-crystalline Chemical Vapor Deposition (CVD) and dedicated front-end electronics readout designed at laboratory. Diamonds are used as solid-state ionization chambers. Their charge collection properties were investigated with various ionizing particles to evaluate the capability of diamond to be a position sensitive detector. Detectors were exposed to 68 MeV proton (ARRONAX) and 95 MeV/u carbon ion beams (GANIL), short-bunched 8.5 keV photons from the European Synchrotron Radiation Facility (ESRF) and 30 keV electron beams at Institut Néel to perform charge collection 2D mapping. Our ultimate scientific objective is to demonstrate that diamond can become a "standard detector"for particle detection, particle counting, time stamps through the design of beam monitors operating with temporal resolutions of 100 ps or less and a high-count rate (from a single particle up to bunches of thousand particles) over a wide dynamic range of beam intensities (fraction of pA up to µA).

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Classification de Session: Applications and Interdisciplinary physics

Classification de thématique: Interdisciplinary research