Plasma-Based Etching Approach for GEM Detector Microfabrication at FBK for X-ray polarimetry in space.

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Gas Electron Multiplier (GEM) detectors are crucial for enabling high-resolution X-ray polarization of astrophysical sources when coupled to custom pixel readout ASIC in Gas Pixel Detectors (GPD), as in the Imaging X-ray Polarimetry Explorer (IXPE), the Polarlight cubesat pathfinder and the PFA telescope onboard the future large eXTP chinese mission. The R&D efforts of the IXPE collaboration have resulted in mature GPD technology [1]. However, limitations in the classical wet-etch or laser-drilled fabrication process of GEMs motivated our exploration of alternative methods. This work focuses on investigating a plasma-based etching approach for fabricating GEM patterns at Fondazione Bruno Kessler (FBK). Our objective is to improve the aspect ratio of the GEM holes, in order to mitigate the charging of the GEM dielectric which generates rate dependent gain changes. Unlike the traditional wet-etch process, Reactive Ion Etching (RIE) enables more vertical etching profiles and thus better aspect ratios (fig .1). Moreover, the RIE process promises to overcome non uniformities in the GEM holes patterns which are believed to cause systemic effects in the azimuthal response of GPDs equipped with either laser-drilled or wet-etch GEMs. We present various GEM geometries with different diameters and pitches, accompanied by extensive characterization (SEM, PFIB, profilometry) of the structural features and aspect ratios. The collaboration with INFN Pisa and Turin will enable us to compare the electrical properties of these detectors and test their performance in their use as electron multipliers in GPDs. Although this R&D work is in its initial stages, it holds promise for enhancing the sensitivity of the IXPE mission in X-ray polarimetry measurements through GEM pattern with more vertical hole profiles. The outcomes of this study have the potential to advance the current technological platforms and improve the capabilities of future space-based X-ray polarimetry missions.

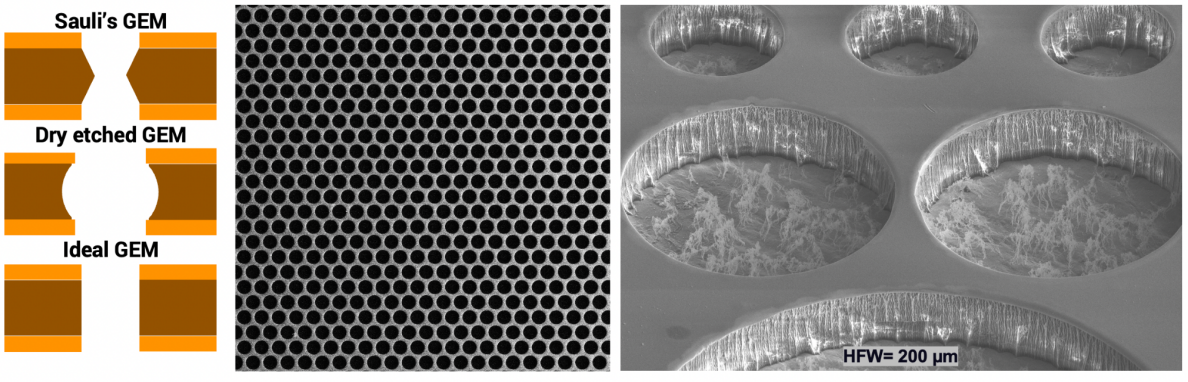

Fig.1: Left: three different geometries for the GEM holes. Center: a typical GEM pattern that we produced with the collaboration between INFN and FBK. Right: a test structure of our gem holes patterns, better vertical hole profile is achieved with RIE compared to wet etching.

[1] Baldini, L., et al. "Design, construction, and test of the Gas Pixel Detectors for the IXPE mission." ***Astroparticle Physics*****133 (2021): 102628.**