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# A 3-dimensional interdigitated electrode geometry for the enhancement of charge collection efficiency in diamond detectors

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**Abstract** – In this work, a single crystal CVD diamond film with a novel three-dimensional (3D) interdigitated electrode geometry has been fabricated with the reactive ion etching (RIE) technique in order to increase the charge collection efficiency (CCE) with respect to that obtained by standard superficial electrodes. The geometrical arrangement of the electric field lines due to the 3D patterning of the electrodes results in a shorter travel path for the excess charge carriers, thus contributing to a more efficient charge collection mechanism. The CCE of the device was mapped by means of the ion beam induced charge (IBIC) technique. A 1 MeV proton microbeam was raster-scanned over the active area of the diamond detector under different bias voltage conditions, enabling to probe the charge transport properties of the detector up to a depth of 8 $\mu$m below the sample surface. The experimental results, supported by the numerical simulations, show a significant improvement in the 3D detector performance (*i.e.* CCE, energy resolution, extension of the active area) if compared with the results obtained by standard surface metallic electrodes.



**Introduction.** – Diamond has extreme physical and electronic properties such as high thermal conductivity, wide band gap, high breakdown field and high carrier mobilities [1,2]. These properties make diamond an ideal candidate for the fabrication of radiation sensors especially for photon and particle detection where other materials hardly reach good performances. It is well known that the electronic properties of diamond can be influenced by recombination and trapping of free carriers on defect-induced localized states in the band gap that may result in inadequate signal response and stability [3,4]. However, the chemical vapour deposition (CVD) offers a technology for producing high-quality, intrinsic homoepitaxially grown layers on low-cost single-crystal diamond substrates under tightly controlled growth conditions [5,6].

To this purpose, detectors based on high-quality homoepitaxially grown CVD single-crystal diamond were developed at the Department of Industrial Engineering of University of Rome "Tor Vergata" for both nuclear particles and photon radiation [7,8].

Different device structures including photoresistive devices and Schottky photodiode both in sandwich or planar interdigitated structure have been reported in the literature [9,10]. Many authors have reported investigations of mono- and poly-crystalline CVD diamond detectors with planar metal electrodes placed on the top of diamond surface [11–14]. However, due to the detection geometry of the device, producing an inhomogeneous electric field substantially confined in the region close to the detector surface, they show a low charge collection efficiency especially for ion detection [13–15]. For this reason, new charge collection geometries have recently been explored through the fabrication of 3D graphitic electrodes

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