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Abstract

Timing Performances and Radiation Hardness of 3D Diamond Detectors †

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Abstract: High time resolution and extreme radiation hardness are key for detectors to be operated in future particle accelerators and in space or medical applications. With respect to these relevant properties, we report here on performances of pixel sensors prepared on mono- and poly-crystalline synthetic Chemical Vapor Deposited (CVD) diamonds, by fast laser modification via multiphoton absorption from a 50 fs, 800 nm, Ti:Sa source. The research has been carried out in the framework of the Timespot experiment of the Italian National Institute for Nuclear Physics (INFN) aimed to achieve both high spatial resolution (55 μm pitch) and very high time resolution (tens of picoseconds) with very radiation tolerant detectors. Timespot exploits the recent 3D electrode architecture to enhance both time resolution and radiation hardness with respect to standard planar silicon and diamond detectors. We present here a major step forward in material engineering and fabrication procedure, yielding a time resolution improvement of our devices from the initial 280 ps to the present 80 ps, bringing this figure of merit very close to that allowed by the more mature 3D silicon technology. Recent results will be presented, and strategies for further improvements will be discussed. Since diamond is known to be a very radiation-tolerant material, it is considered very promising for implementing devices planned for very fast response and radiation hardness. We present results on a thorough study of polycrystalline and monocrystalline diamond sensors irradiated up to a fluence level of 10^{16} n_{eq} (1 MeV)/cm^2. The superior radiation hardness of the 3D architecture is demonstrated with respect to the planar detectors. We have also verified that the radiation hardness increases with increasing bulk electrode density. The results are discussed and compared with other radiation hardness studies carried out on 3D diamond sensors.

Keywords: CVD diamond; diamond sensors; laser engineering; timing measurements; radiation hardness

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