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Characterization of FBK 3D pixel sensor modules based on RD53A readout chip for the ATLAS ITk

3D pixel sensors are the technology of choice for the innermost layer (L0) of the ATLAS ITk detector at High Luminosity LHC. The considered sensors have pixel size of either 25 μm ⊠ 100 μm (25⊠100) or 50 μm ⊠ 50 μm (50⊠50), with one read-out electrode at the centre of a pixel and four bias electrodes at the corners. The former geometry has been chosen for the central part of L0 (barrel), the latter for the lateral rings (endcap). A new generation of 3D pixels featuring these small-pitch dimensions and reduced active thickness (˜150 μm) has been developed to this purpose within a collaboration of INFN and FBK since 2014 [1]. The most recent R&D batches at FBK have been oriented to sensors compatible with the RD53A chip, also taking benefit from using an improved lithographical system [2]. Several sensors of different geometries were bump bonded to RD53A read-out chips at Leonardo (Rome, Italy) and tested in laboratory and at beam lines.
In this paper, we report on the module characterization results, including threshold tuning and noise measurements, and results from beam tests performed at DESY facility on both 25×100 and 50× 50 sensors, irradiated with 70 MeV protons up to a fluence of 1×1016 1 MeV neq cm-2. As an example, Fig. 1 shows the hit efficiency in two modules as a function of the bias voltage. It can be seen that both the 25×100 and 50× 50 modules reach the target efficiency of 97% below 100 V, although the 25×100 initially exhibited an anomalous trend. Moreover, we discuss about the electrical characteristics at wafer level and at module level before and after irradiation, also in comparison with other modules from previous fabrication batches [3].

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