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# Planar pixel sensor development for the CMS Phase II upgrade

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The LHC is planning an upgrade program which will bring the luminosity up to about $7.5 \cdot 10^{34}\mathrm{cm}^{-2}\mathrm{s}^{-1}$ in 2027, with the goal of an integrated luminosity of 3000 $\mathrm{fb}^{-1}$ by the end of 2037. This High Luminosity scenario, HL-LHC, will present new challenges of higher data rates and increased radiation tolerance for the pixel detector ($2 \cdot 10^{16}\mathrm{n_{eq}}/\mathrm{cm}^2$, or equivalently 1 Grad, is expected on the inner pixel layer for 3000 $\mathrm{fb}^{-1}$ integrated luminosity). To build a pixel detector with good performance under these conditions, planar pixel sensors are the baseline technology for layers 2-4, while for layer 1 of barrel and forward pixel sensors, 3D sensors are considered as an option. A variety of n-in-p planar pixel sensors with pixel sizes of 50 × 50 $\mu\mathrm{m}^2$ and 100 × 25 $\mu\mathrm{m}^2$ and active thicknesses between 100 µm and 150 µm have been designed and produced at Hamamatsu Photonics and at FBK on 6 inch wafers. They were bump bonded at Fraunhofer IZM to ROC4Sens and RD53A read-out chips. Apart from the pixel size, the design variants differ with respect to the implantation and metalization geometry as well as the pixel isolation and biasing scheme. To select the most promising design ROC4Sens modules have been irradiated at CERN IRRAD with protons up to $4 \cdot 10^{15}\mathrm{n_{eq}}/\mathrm{cm}^2$, at JSI Triga with neutrons up to $8 \cdot 10^{15}\mathrm{n_{eq}}/\mathrm{cm}^2$, and RD53A modules with protons up to $1 \cdot 10^{16}\mathrm{n_{eq}}/\mathrm{cm}^2$. In this talk results of irradiated as well as unirradiated planar sensor modules tested in the DESY and CERN test beam facility will be presented.

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