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Title:

Development of n^+-in-p silicon microstrip and pixel sensors for HL-LHC in Japan and understanding their performance with TCAD simulations

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Abstract:

Our R&D of radiation-tolerant silicon sensors is originated from the silicon microstrip sensor for the silicon strip tracker (SCT) of the present ATLAS detector for LHC. The development was centered in the high voltage operation required for the LHC.

After successful construction of the SCT tracker, we have been developing next-generation radiation-tolerant silicon sensors for the LHC upgrade (HL-LHC). Our goal is to develop planar-process silicon sensors in p-type 6-in. silicon wafers, n^+-in-p sensors, being highly radiation-tolerant and cost-effective for covering large area of the upgraded inner tracker.

In the design and validation of the n^+-in-p silicon microstrip sensors, radiation damages have been evaluated with miniature sensors, irradiated to 70 MeV protons at CYRIC. Their design and performance have been guided and understood with technology CAD (TCAD) simulations.

In parallel to the development of silicon strip sensors, n^+-in-p planar technology has been applied to pixel sensors for even higher radiation environment. In the 1st prototype pixel sensors, after irradiation and beamtest, inefficient regions in detecting passing-through charged particles were identified in pixel structures, especially associated with the bias rail. New pixel structures were fabricated in the 2nd prototype sensors and are shown to improve the inefficiency greatly. The source of the inefficiency and the improvement in the pixel structures has been also discussed with TCAD simulations.

A new area of development associated with the pixel sensors is the bumpbonding. The bumpbonding is to use industry standard technology, i.e. lead-free, SnAg solder bumps. The bumpbonding of thin (150 μm) sensors and thin (150 μm) ASIC has revealed an issue associated with the thickness. The issue seems to have been resolved by improving the flatness of the sensors and ASIC by depositing compensation in the backside or by improving the vacuum chucking jigs.