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Development of n^+-in-p planar pixel sensor flip-chip modules with quad FE-I4 readout ASIC's

We have developed prototype pixel detector modules for the inner tracker of the ATLAS detector to be upgraded for the high-luminosity LHC. The module is made of pixel sensor and pixel readout ASIC's, being flip-chip bumpbonded. The pixel sensor is an n^+-in-p planar sensor of a size of 2×2 of ATLAS FE-I4 pixel readout ASIC's, called the quad-sensor. Seven such sensors were laid out in 6-inch p-type FZ wafer, with three different gaps between the ASIC's, and thinned to 150 μm. The wafers of the FE-I4 ASIC's were also thinned to 150 μm and deposit with lead-free SnAg solder bumps. The bumpbonding was made specifically by taking care of removing oxidation in the surface of the bump pads/solders of the sensors/ASIC's. Four of the quad-sensor modules, with 16 ASIC's, were bumpbonded by introducing Hydrogen-plasma reflow process (H-SnAg), and in addition, two were by applying solder-flux. The quad-sensor modules were gone through thermal cycles between +/-40℃, irradiation to protons of a fluence of approximately 3×10^15 neq/cm^2. Bump disconnection was checked against the beta-ray response before and after the thermal cycles and the irradiation. No large-area bump disconnection was observed. The modules were evaluated with testbeams and showed good performance.

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