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Performance of high-density indium bump-bonding.

About half of the ATLAS pixel modules have been produced with the Indium bonding technology [1,2].

The building blocks are modules made of a silicon sensor tile (pixel size of 400x50 µm2, with a sensitive area 16,4 x 60,8 mm2) and 16 front-end (FE-I3, 200 µm thick and 7,6 x 10,8 mm2 area) integrated circuits, each serving 18 x 160 pixels. Bumps are at the same time the electrical and the mechanical connection between sensor and electronics and they are a crucial component of the detector assembly. The general ATLAS requirements for bump deposition are:

- a bump pitch of 50 µm with a defect rate < 10-4;
- a density of 5000 contacts/cm2, or 2880 bumps per readout IC

The new ITk ATLAS silicon detector has more stringent requirements for the read-out chip: the new front-end has been developed with a pixel size of 50 x 50 µm2, to cope with high hit rates, in a 65 nm feature size bulk CMOS process, in view of future ATLAS high luminosity pixel applications. In order to reduce the detector material, thinning the sensors down to 100 µm and 150 µm and the FE to 150 µm is foreseen.
From the bumping point of view, the higher density requirement of 40000 contacts/cm2, with the same minimum bump pitch, is achievable. The critical parameters for the bonding process are the larger size of the bonding area, about 20x20 mm2 per front-end chip, together with the requirement of a thinned devices. Handling of such a thin and large chip, planarity with respect to the sensor during flip-chip, deformations coming from internal stress of the chip and/or working temperature during the bonding step, are possible origin of problems for the hybridization step.
The Indium bump bonding technique is an appealing candidate for coping with these problems because it requires just one Under-Bump Metallization (UBM) step and a low (90 ˚C) maximum working temperature of the process. Therefore, a research and development collaboration has been arranged between INFN and Leonardo to develop this process up to the point to produce assemblies with sensors thinned down to 100 µm.

To qualify that the process is coping with these requirements, the ATLAS collaboration tested several prototypes assembled with half size, double chip modules (two 11.6x20 mm2 FEs bonded to a 10.9x41.05 mm2 sensor): results from these prototypes will be presented and discussed.

[1] G.Alimonti et al., Analysis of the production of ATLAS indium bonded pixel modules, Nucl. Instr. and Meth. A 565 (2006) 296
[2] G. Aad et al., ATLAS pixel detector electronics and sensors. JINST 3(07):P07007, 2008.

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