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Module Development for the Phase-2 ATLAS ITk Pixel Upgrade

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For the high luminosity era of the Large Hadron Collider (HL-LHC) it is foreseen to replace the current inner tracker of the ATLAS experiment with a new, all-silicon detector to cope with the occurring increase in occupancy, bandwidth and radiation damage. It will consist of an inner pixel and outer strip detector aiming to provide tracking coverage up to $|\eta|=4$. The layout of the pixel detector is foreseen to have five layers of pixel silicon sensor modules in the central region and several ring-shaped layers in the forward region. This results in up to 14 m^2 of silicon depending on the selected layout.

Detector requirements in terms of radiation hardness and occupancy, as well as thermal performance depend strongly on the distance from the interaction region. Therefore, the innermost layer will feature 3D silicon sensors, due to their inherent radiation hardness and low power consumption, while the remaining layers will employ planar silicon sensors with thickness ranging from 100µm to 150µm. All hybrid detector modules will be read out by novel ASICs, implemented in 65nm CMOS technology and thinned to 150µm, which will be connected to the silicon sensors using bump bonding. With about 4 104 pixels per cm^2 the bump bond density is a much higher than in previous hybrid detectors.

With the recent availability of the first prototype readout chip, the RD53A, module development for the ITk Pixel Detector is entering a new phase. Numerous modules will be assembled to test the performance of bump bonding of objects of realistic area, very small

thickness and high bump bond density, as well as to finalize studies of the module performance with pixel pitches of 50x50μm^2 and 25x100μm^2 on the sensors. The stack-up of these hybrid pixel modules can be seen in Fig. 1. Flex circuits are glued on top of the modules for connection and routing of services which have to be qualified too. Moreover, tests of the new serial powering scheme for low voltage supply of the modules will be done as part of the prototyping program. The quality assurance criteria for the production of the final detector modules are verified, including mechanical properties like module flatness as well as electrical tests of the functionality of the modules and the bump bond quality.
We will present the latest results from the assembly and characterization of the prototype modules. Important qualification steps of the module design will be discussed.

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