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Pre-Production Testing of the AMACStar ASIC at Penn for the ATLAS ITk Detector

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The high-luminosity upgrade to the LHC (HL-LHC) requires an all new, silicon-based inner detector (ITk strips). The AMACStar is one of three radiation hard ASICs that will be installed on the ITk strip modules. Its function is to autonomously monitor and control the temperatures, voltages, and currents in the detector modules, an essential feature for the ITk detector modules. A comprehensive probe-station testing software and procedure have been developed in order to test the digital and analog functionality of every AMACStar. A detailed grading scheme is then applied to determine which chips should be installed on the modules.

Summary (500 words)

In light of the high-luminosity LHC (HL-LHC), the part of the ATLAS inner detector will be replaced with a silicon-strip charged-particle tracking detector (ITk strips) to satisfy the new radiation, granularity, and data readout rate requirements. The AMACStar (Autonomous Monitor and Control) is one of three ITk ASICs (application-specific integrated circuits) to be installed in the ITk strip modules. It is designed to monitor and control temperatures, voltages, and currents in the detector modules. This is an essential function for the ITk detector: the ASIC can autonomously (and effectively) identify hazards in the modules, controlling and preventing them from becoming catastrophic.

The ITk ASICs are produced on wafers containing several hundred chips, and the ITk detector will require approximately 18000 total AMACStars. In order to ensure that each AMACStar chip works and performs as expected, a comprehensive probe-station testing software and procedure has been been developed. The testing software examines the entire digital and analog functionality of a given AMACStar in a few minutes. The probe-station setup can then run this software over the 487 AMACStars on a wafer. From here, extensive digital and analog grading parameters are applied to evaluate the performance of every AMACStar and determine which chips should be installed on modules.

The grading parameters are implemented into the wafer analysis and plotting software. As such, they are meant to rigorously and efficiently identify possibly problematic AMACStar chips on the wafer. We have selected a total of 43 logic and 140 analog parameters, which ensure that we examine every important function and measured value of the chip, for each chip on the wafer. Using the parameters, we sort the AMACStar chips into three categories: Good, the AMACStar chips that perform perfectly; Accept, those that have some imperfections in their analog functionality but may still be used; and Bad, those that have one or more major issues in either their digital or analog functionality. Our yield is measured only based on how many 'Good' chips we have.

I will present the probe-station setup and probing results of the pre-production AMACStar wafers. The measured pre-production yield for AMACStar is over 90%, which exceeds expectations.

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