Contribution ID: **135** Type: **Oral**

Development of a novel low-mass module flex PCB using nano-wire-based flip-chip interconnection

Friday, October 4, 2024 9:20 AM (20 minutes)

In order to reduce the material budget and maximize the active area of sensors used in future experiments, a 30um thick lightweight flex has been produced. The presented fabrication technology coupled with novel interconnection technologies allows for compact packaging with a direct attachment of the chip connection pads to the flex. Beyond interconnection technologies such as Anisotropic Conductive Films and gold studs, we demonstrate the successful application and bonding of nanowires using bonding principles such as sintering and glue-assisted bonding. This contribution will present the module concepts as well as the first electrical and mechanical results from demonstrator modules.

Summary (500 words)

The MALTA2 CMOS monolithic silicon pixel sensors have been developed in the TowerJazz 180 nm CMOS imaging process. They entail an asynchronous readout scheme, compatible with HL-LHC requirements, and have been tested to be radiation resistant to 3 1015 neq cm-2.
A significant effort is underway to develop large area and lightweight modules using MALTA2 sensors as monolithic sensor demonstrators. The novel flex PCB is designed to reduce the material budget as much as possible while ensuring dense packaging maximizing the active area in the detector. Scalable interconnection technologies enable production targeting large detector surfaces. These technologies include ACF/ACP (Anisotropic Conductive Film/Anisotropic Conductive Paste), epoxy-supported gold studs, and nano-structured pads (nano-wires). Nano-wires have been deposited with a diameter of 0.4 –0.6 µm and a length of 3-5 µm onto MALTA2 sensor pads. The optimized process has demonstrated a near 100% pad yield, enabling usage on large chip quantities at wafer level. It further allows for the reliable bonding of sensors housing a large number of bond pads. We show how nano-wires can be used in different bonding methods such as cold welding, copper sintering, and glue-assisted bonding enabling the bonding of a wide variety of pad geometries. Current smallest interpad distances on MALTA2 are 32 µm while the process has to potential to interconnect pitches down to 8 µm. The presented interconnection technologies are essential to overcome the minimal distance requirements of the wire bonding process while reducing parasitics, and enabling denser packaging over a wide signal frequency range.
To demonstrate the capabilities of the flip-chip bonding technology for minimal material module integration, a flexible PCB with a thickness of ˜30 µm and track widths down to 17 µm has been produced. This allows for design flexibility in the support structure, including features such as flaps providing backside biasing onto the rear of the chips it houses. This structure can provide a homogeneous electrical field in the sensor which contributes significantly to its stable performance. Besides the sensor integration on the flex using multiple technologies, the reliable integration of passive components as well as a 140-pin connector on a 5 µm copper layer via reflow solder is shown.
This talk will summarize the test results of demonstrator modules as well as of the interconnection studies. An outlook for a compact silicon pixel module concept as well as the necessary interconnection technologies for future experiments, with a high active area, minimal material, and potential for scalability will be presented.

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Session Classification: Packaging and Interconnects

Track Classification: Packaging and Interconnects