Module assembly technologies for the Silicon Tracking System of the CBM experiment at FAIR

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CBM at FAIR, GSI

- Compressed Baryonic Matter (CBM) experiment at FAIR investigates the QCD phase diagram at high baryon densities
- High energy nucleus-nucleus collisions (10^5 - 10^7 Au+Au collisions/s)
- SIS100: ion beam energies between 2 and 14 AGeV, protons up to 29 GeV
- SIS300: ion beam energies up to 45 AGeV, protons up to 90 GeV

Silicon Tracking System (STS)

- Core detector of CBM located inside the dipole magnet
- Track reconstruction and momentum determination of charged particles
- Track multiplicity up to 700 per central Au+Au collision in the aperture of 2.5° < θ < 25°
- Momentum resolution dP/P ~ 1%
- Lifetime fluence up to 1 x 10^18/nm² in innermost region for SIS300

Current interconnection method: TAB bonding

- Current interconnection technology used by GSI and JINR
- 32 Al cables per detector module
- Several test modules already built by GSI and JINR
- Tested at KIT: able to perform TAB bonding: mechanical jigs need to be adjusted to TAB bonding machine
- Copper TAB bonding cables as alternative to Al cables

KIT copper microcable

- Low mass, low capacity copper microcable designed at IPE
- Double-layered design: 16 instead of 32 cables per module
- Several bond pad surface finishes possible
- Delivered in sheets of 8 cables

Novel approach: Bonding of die on flex

Gold stud bump bonding + solder paste printing

- Printing of fine-grain solder paste type 7 (2-11 µm grain size) on double-layered copper microcable
- Gold stud bumping (60 µm) on ASIC and sensor
- High-density die on flex interconnection of ASIC to cable with Femto fineplacer
- High-density die on flex interconnection on sensor side with in-house bonding machine
- Underfill application for spark protection and mechanical stabilization

Sensor-side: in-house bonding machine

- Two-camera system
- Four stepper motors in x, y, z and phi with sub-micron accuracy for precise alignment.
- Underfill application possible

Advantages:
- Fast production method
- Half the amount of cables: facilitates production
- Potentially better production yield
- Possibility of reworking the module

Summary/Outlook

- Bonding of die on flex is a promising high-density interconnection technology that might also be interesting for other future experiments
- Two production methods under development:
  - TAB bonding
  - Bump bonding
- Build-up of complete proto module (1 sensor + 16 cables + 16 ASICs)
- Electrical tests and comparison of the two interconnection technologies
- KIT is one of three production centers of STS for CBM
- Production will start 2019/2020, production volume is about 300 (1/3 of whole volume) detector modules