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The MVD of the CBM experiment at FAIR: Selected Aspects of Mechanical Integration

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The Compressed Baryonic Matter experiment (CBM) at the future FAIR facility at Darmstadt (Germany) explores the phase diagram of strongly interacting matter in the regime of highest net baryon densities with numerous probes, among them open charm. Open charm reconstruction requires a vacuum compatible Micro-Vertex Detector (MVD) with unprecedented properties, arranged in (up to) four planar detector stations in close vicinity of the (fixed) target. The CBM-MVD requires sensors featuring a spatial resolution of < 5 μm, a non-ionizing radiation tolerance of > 10^{13}neq/cm^2, an ionizing radiation tolerance of 3 Mrad, a readout speed of few
10 s/frame, and the integration in detector planes with several per mille X0 material budget only.

In our contribution we will address aspects related to the mechanical integration of the CBM-MVD, among those: Vacuum compatibility, glue development, commissioning of the 50 μm thin CMOS sensors with standard probe cards, lithography on CVD diamond.

The prototyping phase of the MVD addressed several issues related to sensor integration into the vertex detector [1], however, the vacuum compatibility of the approach used has not been studied up to now. To do so, assembled beam telescope stations were placed inside a vacuum chamber and successfully run for several days at the pressure of about $2{\cdot}10^{-6}$ mbar. Despite the first results are very promising, a full validation of vacuum compatibility requires further tests which are currently addressed. Regarding the electrical connectivity of the sensors we study option to guide electrical traces close to the sensors with minimum material budget (dedicated flex, lithography on carrier material), as well as dedicated feed-throughs for a vacuum chamber.

Construction of the CBM-MVD station with minimum material budget of 0.3% x/X0 for the 1'st station up to 0.5% x/X0 for the 4'th station is an ambitioned task. Therefore, developing a dedicated thin read-out flex is mandatory. In addition, together with our partner institutions (GSI Darmstadt and Hochschule RheinMain Russelsheim), we have addressed studies aiming at verifying a feasibility of employing Al traces on a CVD diamond carrier using photolithography methods. Here, we report on "phase-1" of the project, which focuses on placing aluminum traces on CVD diamond.

Imperfections in CMOS process as well as further dicing and thinning procedures may reduce the final yield of sensors to be mounted in the detector stations to about 60-70%. To select sensors with the best characteristics, probe-testing prior to integration is mandatory. Due to the fact that the MVD sensors are thinned to 50 um, which is not a standard industrial thickness, feasibility of needle tests of such thin devices was addressed at IKF with a CMOS sensor named MIMOSA-26 [2]. A dedicated probe-card hosts 65 tungsten needles with minimum pitch of 120 μm provides all necessary signal lines to operate the sensors and read a data stream out. The first successful tests of 50 μm thin precursors of final CBM-MVD sensors will be discussed here.

[1] M. Koziel et al., Nuclear Instruments and Methods in Physics Research A 732 (2013), pp. 515–518C.

[2] G. Voutsinas et al, Nuclear Physics B - Proceedings Supplements, Vol. 215, Issue 1, (2011), pp. 48-50.

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