# Lithographic integration of Aluminum read-Out traces on CVD diamond for the CBM micro vertex detector*

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The Micro Vertex Detector (MVD) [1] of the Compressed Baryonic Matter (CBM) experiment at FAIR aims at a challenging material budget of only a few per mille radiation length for each of the detector stations. This allows for the high-precision secondary vertex reconstruction needed to identify e.g. rare open charm particles emitted in violent heavy ion collisions. The detector will be operated in vacuum and relies on dedicated CMOS monolithic active pixel sensors (MAPS) [2] thinned to 50 $\mu$m, mounted on sheets of 200 $\mu$m thick poly-crystalline CVD diamond [3], which features a thermal conductivity of about 2000 W/mK, i.e. about four times the one of copper, and a high mechanical stability (Young's modulus of 1050 GPa). A conventional sensor module comprises the carrier for mechanical support and cooling, the sensors, dedicated glue and thin flex cables used to control and read-out the sensor. A standard method to connect the sensor is wedge bonding of 25 $\mu$m aluminum wires. This concept was realized for the MVD prototype [1]. A feasibility study is focusing on the option to merge the functionalities of the carrier and the read out, aiming at further improving the material budget and at the same time reducing the steps of integration by sparing the dedicated flex cable.

The technology of choice is photolithography of microscopic traces directly on the CVD diamond carrier for reading out and biasing the sensor. Employing aluminum for the traces with a thickness of up to 3 $\mu$m is mandatory for reducing the material thickness and the probability of $\gamma$-conversion. However, it triggers questions related to mechanical and electrical properties, such as adhesion and conformity of the traces as well as impedances, respectively. These questions were addressed in a study accomplished by GSI Darmstadt (detector laboratory) and Hochschule RheinMain (IMtech) Rüsselsheim, w.r.t. the lithographic part, and the IKF (characterization). Here, we report on the first step of the project, which focuses on placing dedicated aluminum traces on CVD diamond.

Figure 1 depicts the final demonstrator module. Part of this module, as indicated in the plot, is subject of this report. Different lithographic techniques have been explored, focusing on adhesion reliability, realizing rather thick traces of 3 $\mu$m, and getting the known effect of underetching under control. For example, chemical (wet) etching has been contrasted to the lift-off technique. Figure 2 depicts typical pictures of the samples under evaluation at the IKF.

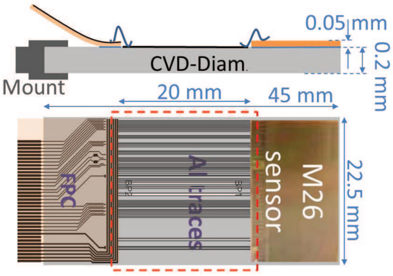

Figure 1: The demonstrator, comprising the sensor ("M26"), the CVD diamond carrier with Al traces and the flex cable to connect to the read out. The broken red line depicts the part of the project reported here.

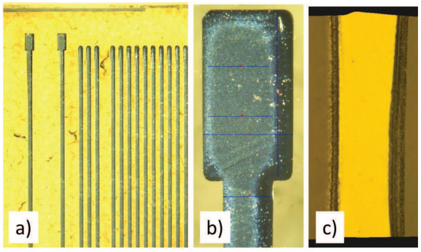

Figure 2: Pictures of Al traces with typical widths of 50 - 100 $\mu$m attached to the CVD diamond carrier: a) different geometries, b) zoom of a pad, c) typical under-etching.

The electrical characterization in in progress, focusing on high-precision measurements of resistances and line-to-line capacities in view of operating a dedicated pixel sensor. To do so, the Al traces have been connected by means of wire wedge bonding, so far revealing no problem with the adhesion of the 50-100 $\mu$m wide Al traces to CVD diamond surface. This has to be confirmed with pull tests. The electrical characterization will also allow for assessing the conformity of the traces, e.g. with respect to the trace thickness. In a next step, the employed processes will be further optimized, based on the results, also exploring the option of providing up to 5 $\mu$m thick Al traces, before preparing the final demonstrator hosting a sensor chip.

## References

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

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