Application for Transnational Access: Usage of the EUDET telescope at CERN test beam

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on behalf of the ATLAS DPix collaboration

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For the LHC phase I upgrade a new innermost layer for the ATLAS pixel detector is being developed, the Insertible B-Layer, IBL. The sensors at a radius of about 3.7 cm will have to withstand an expected fluence exceeding 5x10^{15} particles/cm^2 in 5 years. At this fluence current silicon sensors cease to function. Due to its large bandgap and high displacement energy, diamond is an intrinsically very radiation hard material. Combined with its fast charge collection, its low dielectric constant and the absence of thermally generated leakage current, diamond is a very interesting detector material for the sensors close to the beam.
To test the performance of polycrystalline CVD diamond sensors test beam measurements will be performed in the CERN SPS testbeam area between 9^{th} and 23^{th} of august 2010. The EUDET pixel telescope will be used for tracking and triggering purposes. We would like to apply for travel support for **5** people for 15 days.

1 Introduction

The current ATLAS Pixel Detector is designed to withstand a non-ionizing dose of up to 2x10^{15} n_{eq} cm^{-2}. The innermost layer will accumulate this dose after about five years of operation and will start to degrade. Therefore a new pixel layer will be inserted close to the beampipe. This small radius of 3.7 cm results in an expected lifetime dose of about 5x10^{15} n_{eq} cm^{-2}.
Chemical Vapor Deposition (CVD) diamond has a number of properties which make it an attractive material for detector applications in harsh radiation environments, such as the Innermost B-Layer radius. Its large band-gap (5.5 eV) and large displacement energy (42 eV/atom) make it a material that should be inherently radiation tolerant with very low leakage currents. Its small dielectric constant (5.7) make it a material with low detector capacitances and thereby, low-noise performance of the associated front-end electronics. Its large thermal conductivity (between four and five times that of copper at room temperature) make it a material whose devices may be operated without cooling. CVD diamond is being investigated by the ATLAS DPix collaboration [1].

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2 Research areas

2.1 Production and industrialization of diamond sensors

Over the last few years the production of high quality diamond material has become much more reliable with charge collection distances routinely exceeding 300 μm. This allowed the production of several full-size, 2x6 cm^2, ATLAS Pixel modules from pCVD wafers, as shown in 1. This is the envisioned sensor material for IBL modules.

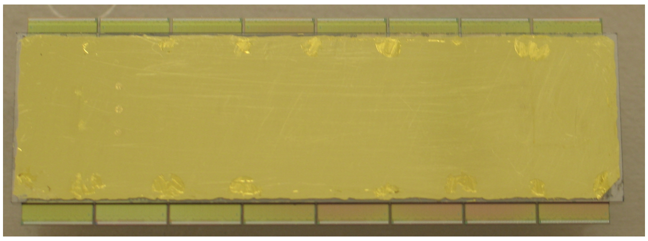

Figure 1: Full size pCVD ATLAS pixel module equipped with 16 FE-I3 readout chips using solder bump technology at IZM Berlin.

The metallization and bump bonding of these sensor tiles is gradually being transfered to our industrial partner, the Fraunhofer IZM in Berlin. This will allow to reduce the costs of the sensor production and enable large scale production for the IBL project.

2.2 Radiation hardness

Several samples of both polycristalline (pCVD) and singlecristalline (scCVD) CVD diamond sensors have been irradiated at various facilities, using protons, neutrons and pions of different energies, to study the development of radiation damage in these materials.
Recent results indicate that both pCVD and scCVD diamond is sufficiently radiation hard to withstand fluences as expected in the phase I upgrade of the ATLAS pixel detector.

2.3 Performance of a pCVD sensor

Due to its better availability in sample sizes appropriate for detector production, pCVD diamond is the most likely choice for a diamond IBL sensor.
Several studies are currently working to evaluate the performance of this material in terms of spatial resolution, charge collection efficiency, and hit-efficiency before and after irradiation. Especially the effects of the increased trap density at the grain boundaries has to be studied in detail.

3 Measurement program

The measurement program for this testbeam period will concentrate on the spatial resolution and the charge collection efficiency of a full-size ATLAS pixel

module with pCVD sensor. To study the influence of the grain boundaries on these quantities, the excellent pointing resolution of the EUDET telescope is crucial.
The sample has been metallized and bump bonded at IZM and is one of the first samples ever to be fully produced by an industrial partner. This will give us the possibility to evaluate the quality of both metallization and bump bonding under operational conditions.

4 People and Funds

The people participating in the measurements and the setup of the system are members of the ATLAS DPix R&D collaboration. The preparation of the testbeam is coordinated by Jens Weingarten (G̈ttingen University) in close contact with Matthias George (Göttingen University) and Fabian Hügging (Project leader of the TA project, Bonn University). A travel support for 5 people from Bonn and Göttingen University who will be participate in the testbeam effort at CERN for the period between August, 9^{th} and August, 23^{th} is requested.

References

[1] H. Kagan, M. Mikuz, W. Trischuck, *Diamond Pixel Modules for the High Luminosity ATLAS Inner Detector Upgrade*, https : //edms.cern.ch/file/903424/1/ATLAS$_{\text{D}}$iamond$_{\text{R}}$D$_{\text{v}}$8.pdf, 2007