High Voltage Monolithic Active Pixel Sensors for the PANDA Luminosity Detector

C. Motzko for the PANDA Luminosity Group

Luminosity determination at PANDA

Measurement by normalization to the elastic antiproton proton cross section at very small scattering angles (\( \Theta = 3 - 8 \) mrad)

Reconstruction of tracks via 4 detector planes

Backtracking to interaction point through complex magnetic fields

Requirements

- High angular resolution
- Low material budget
- Measurement at smallest angle
- Minimal distortion of the beam

Sensors

Spatial Resolution

Performance

Prototype performance studies at MAMI 1 GeV electron beam and at DESY 5 GeV electron beam

- Electron detection efficiency >99%
- Hit resolution given by pixel cell size
- Time resolution: 7 ns
- Laboratory measurements give S/N >15

Vacuum

Ion Getter Pump

Transition Cone

Separation of beam pipe vacuum

Proof of Concept

- Pumping for 2.5 weeks without getter pump
- Box: 5 \times 10^{-7} \text{ mbar}
- Beam Pipe: 6 \times 10^{-7} \text{ mbar}

Cooling

- Target Pipe EMC Dipole
- Small scale prototype
- Full Setup

Simulation

- Ideal transition between aluminum and CVD diamond
- Good agreement between simulation and measurement

Cooling Test with Copper Dummies

- 210 W electrical load
- Cooled with ethanol at -20 °C up to 50 °C at module tips

Frontend Board

- HADES Trigger and Readout Board
- HEP for OOP connection to PC
- Four peripheral FPGA for sensor IO

Support PCB

- On both sides
- Support electronics for sensors
- Power dissipation components attached to the aluminum surface

Full-scale

- Aluminum Flex Cable
- High density connector
- Two layers: 14 µm thick traces:
- Traces width/pace = 50 µm

Rigid Flex Cable

- 570 mm long
- Three layers for flex area
- 40 differential pairs
- High voltage

Support electronics for sensors

- Power dissipation components attached to the aluminum surface

CVD Diamond

- Highest thermal conductivity

Radiation length

- 900 μm ≈ 300 μm silicon
- 6.5% glue
- 27.6% sensor
- 33% diamond substrate
- 1.3% coating
- 5.1% flex cable substrate
- 16.3% aluminum traces
- 16.3% diamond substrate

Sensor

- 2 x 2 cm²
- 50 µm thick
- Wirebonded to cable
- 10 glued from both sides

High Voltage Monolithic Active Pixel Sensor

- In pixel amplification
- Anamorph and digital readout integrated:
- Each hit converted on-chip into pixel address and time-stamp
- Zero suppressed data sent through UDPs output link at 800 Mbps

Bias

- Voltage
- + HV

Bias resistance

N-well

P-substrate

P-well

Tune DACAC coupling

Amplifier

PMOS

NMOS

Latch

Discriminator

CR-RC Bus driver

Vacuum Box

- 10⁻⁷ \text{ mbar