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Detection of High Flux Synchrotron Radiation Based on Diamond Detector for HEPS

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Abstract

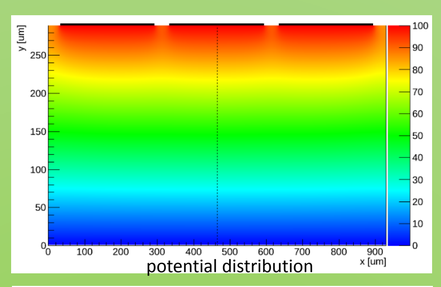
High Energy Photon Source (HEPS) with a beam energy of 6GeV and emittance less than 1.0nm·rad will be constructed in China, which can provide high-brilliance hard X-ray in the order of 10^{13}. The broadband and high-flux monochromatic beam flux and white beam flux need new detector other than the ion chambers for measurement in case of saturation under high-flux conditions.

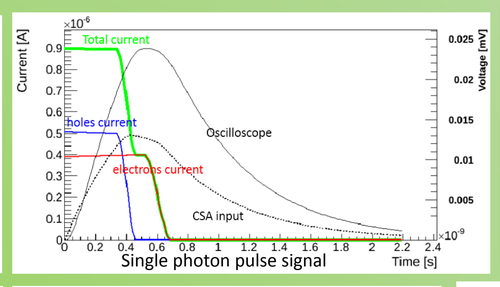
Diamond X-ray detector for the beam position monitoring and high flux X-ray detection is developing for High Energy Photon Source in China. The diamond detector is designed with multilayered structure to realize the function of beam position monitoring and X-ray intensity measuring. The first layer is the four-quadrant-like position-sensitive device and the other layers are fabricated to single pixel for X-ray intensity measuring. The diamond detector has advantages over other detector materials: a low atomic number resulting in a low absorption cross-section when used as beam position monitor and a high radiation and wide linear range when used as beam intensity measuring. The polycrystalline chemical-vapor-deposition diamond detectors with aluminium contact have been tested at 1W2B beamline at Beijing Synchrotron Radiation Facility (BSRF).

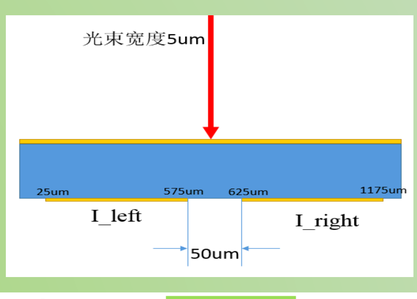
Characters of diamond detector

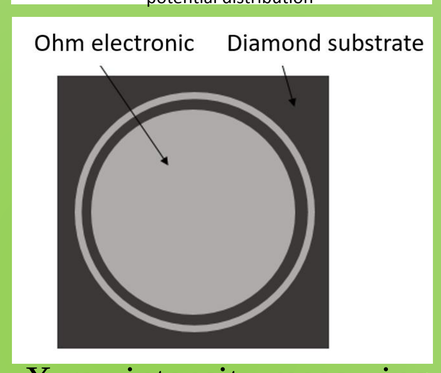
- Fast response time --ns response for single photon
- Large dynamic range -- current from pA to mA
- Good linearity
- Low leakage current --pA or fA
- Radiation hardness

Physical design of diamond detector

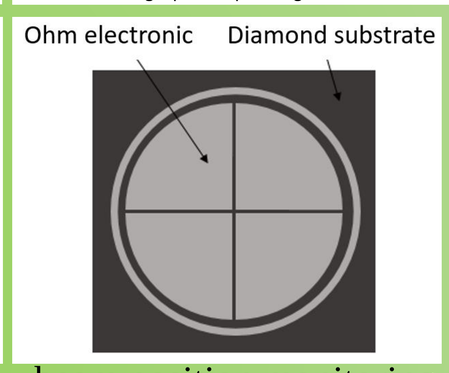




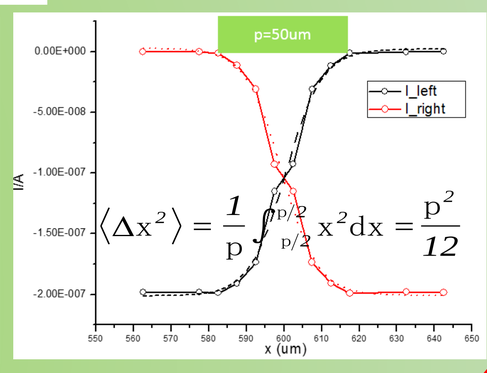




X-ray intensity measuring



beam position monitoring



First test at BSRF

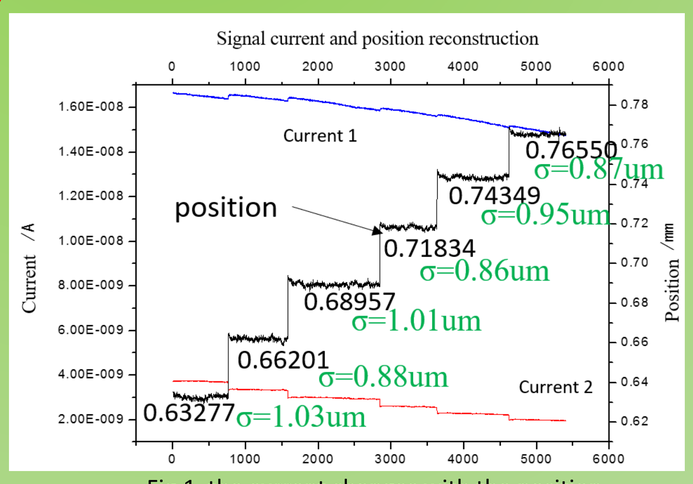


Fig.1 the current changes with the position

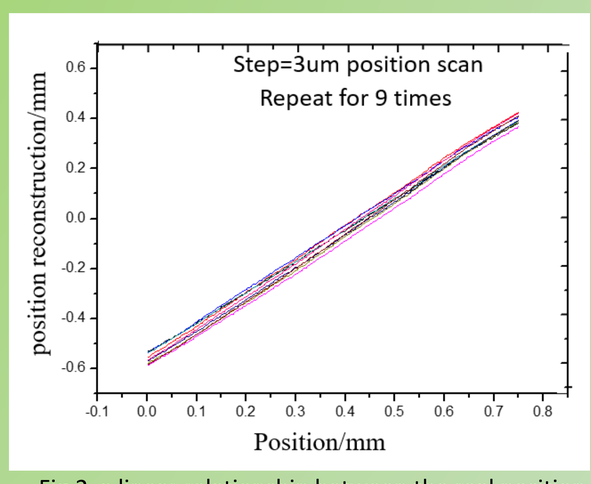


Fig.2 a linear relationship between the real position and the reconstructed position

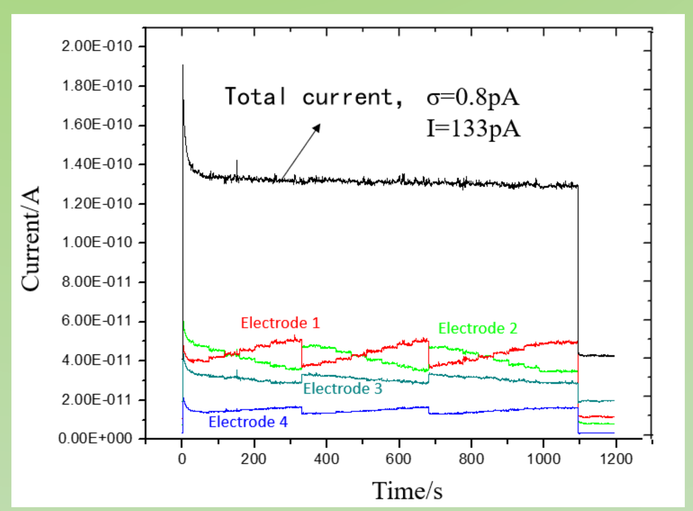


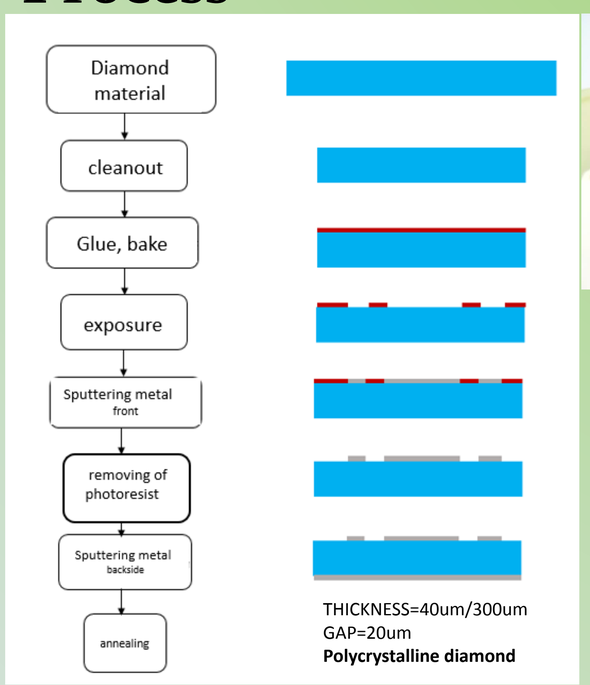
Fig.3 the total current and the four electrodes' current

Position scan in one direction

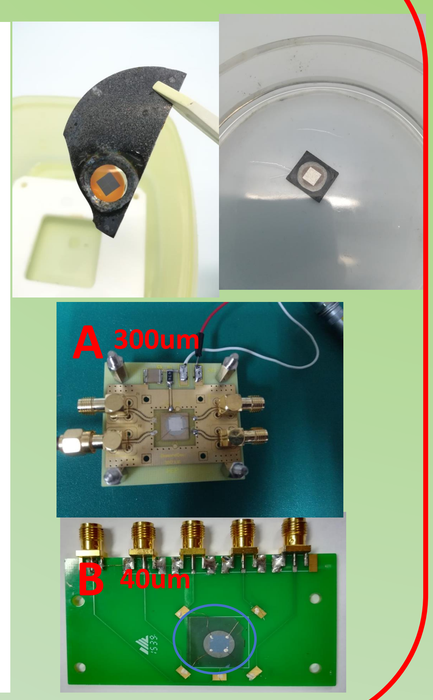
$$X = \frac{I_1 - I_2}{I_1 + I_2}$$

- Position resolution
  σ =1um with gap=20um
- Total current=133pA
  with leakage current=20pA
  σ=0.8pA
- X-ray light spot>2mm×2mm

Process

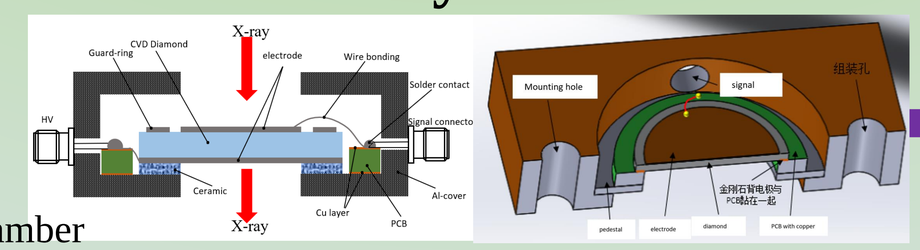


THICKNESS=40um/300um
GAP=20um
Polycrystalline diamond

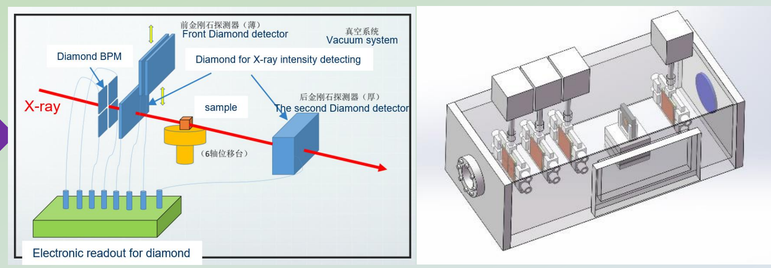


Future design of the diamond detector system

- Diamond detector system for synchrotron radiation experiment (for example XAFS)
- Beam position monitor and X-ray intensity measuring
- High integration lever instead of the ion chamber



A package sketch of the diamond sensor



Experiment system with diamond detector for X-ray Absorption Spectroscopy