X-ray beam position and intensity monitoring based on electronic readout of single crystal diamonds

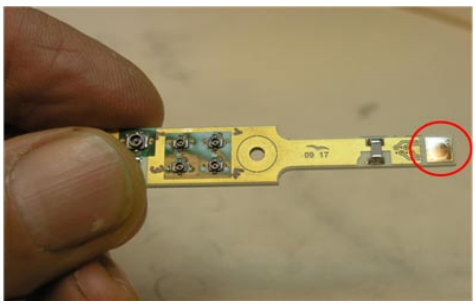
J Morse[1], M Salomé[1], K Detlefs[1], H Graafsma[2], K. DesJardins[3], M Pomorski[4], B Solar[5], E Berdermann[6], J Smedley[7]

[1]European Synchrotron Radiation Facility, Grenoble, 38043, France
[2]Deutsches Elektronen-Synchrotron, Hamburg, 22607, Germany
[3]Synchrotron Soleil, Gif-sur-Yvette, 91191, France
[4]Commissariat à l'Energie Atomique et aux Energies Alternatives, Gif-sur-Yvette, 91191, France
[5] Dromedar D.O.O., Žabnica, 4209, Slovenia
[6]GSI Helmholtzzentrum für Schwerionenforschung, Darmstadt, 64220, Germany
[7]Instrumentation Division, Brookhaven National Laboratory, Upton, NY, USA

Abstract:

'Electronic grade' (<5ppb of B, N impurities) single crystal diamond is grown homoepitaxially by chemical vapour deposition and then polished to a thin (<100µm) plate. With suitable surface electrical contacts, a 'solid state ionization chamber' is formed which is used to intercept synchrotron X-ray beams and provide continuous measurement of the beam intensity and position. The thin diamond crystal absorbs only a small percentage of the incident beam, and with sub-nanometer roughness surfaces it causes little degradation to the beam quality and coherence. At 3rd generation synchrotrons, X-ray beams are now routinely focused to <1µm and frequently to <100nm. Compact monitoring devices with the ability to reach submicron resolutions at near kHz bandwidth are required to measure position and intensity variations associated either with movements of the beamline optics or the X-ray source itself. At the ESRF ID21Microscopy beamline we have demonstrated measurements with <15nm of position noise using quadrant electrode diamond devices with electrometer readout [1]. At DESY, narrowband radiofrequency diamond readout [2] has recently been used to characterize monochromator vibrations above 100Hz at the P11 crystallography beamline. We have also fabricated and installed devices with resistive, 'diamond like carbon' contacts at ESRF and Soleil which provide submicron resolution and linear position response over a >2mm working range [3]. We are now working on the development of thin <10µm membrane diamonds for beam energies down to ~3keV, while at BNL-NSLS, a split quadrant diamond system has been in use for over a year for white beam monitoring [4]. We will present the practical issues associated with the fabrication of these diamond devices and discuss their performance limits.

[1] J Morse, M Salomé, E Berdermann, M Pomorski, J Grant, V O'Shea, P Ilinski, Mater.Res. Soc. Symp. Proc. (Fall 2007), 1039 P06-02
[2] J Morse, B Solar, H Graafsma, J. Synch. Rad. (2010) 17, 456–464
[3] Pomorski, M, Ciobanu, M, Mer, C, Rebisz-Pomorska, M, Tromson, D and Bergonzo, P (2009), Phys. Stat. sol. (a) 206:2109–2114
[4] E Muller, J Smedley, J Bohon, X Yang, M Gaowei, J Skinner, G De Geronimo, M Sullivan, M Allaire, J Keister, LBerman Heroux *J. of Synch. Rad.* (2012) 19**,** 381-387



A mounted quadrant diamond position monitor for the ESRF ID21 Microscopy Beamline: the 30 µm thick diamond sensor is circled in red.