Characterization of Diamond Crystal X-Ray Phase Retarder

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An x-ray phase retarder based on a diamond single crystal diffracting in the asymmetric Laue geometry has been characterized at the X25 wiggler beamline at the National Synchrotron Light Source (NSLS). The forward diffracted (transmitted) beam, using the (111) Bragg planes in a 0.5 mm thick wafer with an (001) surface normal, was employed. For polarization analysis, a GaAs(111) crystal was oriented for the (222) reflection and scanned through the three-beam diffraction condition. From careful analyses of the analyzer crystal's three-beam diffraction lineshapes and rocking curves, all four Stokes-Poincare polarization parameters of the beam transmitted by the diamond crystal were determined, for several settings of the diamond about its (111) rocking curve. At 7.1 keV, with the beam incident upon the diamond phase retarder essentially completely linearly polarized (horizontally), the Stokes-Poincare polarization parameter $P_3$ (which represents the degree of left- or right-handed circular polarization) was determined to be $-0.95$ and $+0.87$ at diamond crystal rocking angles of $-0.02$ and $+0.02$ deg relative to the rocking curve center, respectively, in good agreement with calculation and indicating excellent performance of the phase retarder as a circular polarizer (see Figure 1). The use of thin (001) oriented diamond crystal plates (which are the most readily available diamond crystals) combined with use of the transmission Laue geometry (which makes alignment relatively straightforward) facilitate the application of diamond crystals as x-ray phase retarders.

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