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Channelling radiation of electrons in high-quality HPHT diamond single crystals

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Abstract content
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The channeling phenomenon applies to the motion of charged particles within a crystal lattice whereby the velocity is closely aligned with atomic rows (strings) or crystal planes. The motion is governed by many correlated collisions with the crystal atoms. As a result, the particles are steered gently along strings or planes and cross-sections associated with the interaction of charged particles with matter are substantially changed in comparison to amorphous matter. Although the channeling potential depths in the laboratory frame are only of the order of some tens of eV, transitions between quantum states for the transverse oscillatory motion may result in photons with energies in the range between keV to multi MeV if the relativistic particle energies are in the range between a few MeV to some GeV, respectively. This so called channeling radiation is well studied. There is however renewed interest based on the prospect of channeling within a periodically bent crystal. In this case, there also be crystal undulator radiation which may be in the gamma regime. High quality synthetic HPHT diamond single crystals with thicknesses varying from 40μm to 500μm were used for detailed studies of channeling radiation. The radiation spectra and dechannelling length, were measured using electron beams with energies of 450 MeV and 855 MeV for (110) and (100) planar channelling conditions. The dechanneling phenomenon in bent crystals can be inferred from that of regular crystals using calculations based on the Fokker-Planck equation where the centrifugal force accounts for the undulator motion. Companion studies of synchrotron based X-ray diffraction white beam topography of all the diamond crystals were used in order to visualize the defects in the crystals and deduce their influence on the channelling effect.

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