Synchrotron radiation X-ray beam profile monitor using a CVD diamond film

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Diamonds is an attractive material in synchrotron radiation beam monitoring, due to their stability against high thermal loads, large heat conductivity, large transmittance, and small absorption of X-rays. For applications in synchrotron radiation beam monitors, many researchers have studied the photoconductive property of CVD diamonds. In such applications, electrodes must be present on diamond to apply voltage bias and detect current signals.. When it is required to obtain not only the beam position but also the beam profile, many microstrip metal electrodes coated on the diamond surface are used for determining the two-dimensional distribution of the beam intensity; further, fabrication of such electrodes requires multistep patterning procedures.

We demonstrate here another type of beam profile monitor that utilizes photoluminescence from chemical-vapor-deposited (CVD) diamond films penetrated by a X-ray beam. It can provide a beam profile without electrodes and multi-channel signal processors. The spatial resolution is not affected by electrode size but depends on the film uniformity.

A diamond film was grown at Kobe Steel Ltd. on a 0.5-mm-thick Si (100) substrate by using a microwave plasma CVD system. The film was deposited on one side of the substrate and had a thickness of 30 µm. In the central region, the substrate was removed by using an etching treatment to form a transparent area with a diameter of 10 mm. In this area, only the diamond film is remained The CVD diamond film on the Si substrate was mounted on a water-cooled copper holder in a vacuum chamber.

The experiments were performed at the BL46XU whose light source is an in-vacuum hybrid undulator. Using the synchrotron radiation calculation code SPECTRA, the photon flux obtained per second through the slit was estimated to be less than 2×10^{16} photons/s; and the power was estimated as 150 W, for a gap value of 8 mm. The beam penetrated perpendicularly to the diamond film. A 12-bit camera-link CCD camera with a macro-zoom video lens and spectrometer inclined at 45 degrees to the beam-irradiation point on the surface of the diamond film are used to acquire the images and spectrums of the PL through the two sapphire view ports. The vacuum chamber was installed at a distance of 34 m from the light source point. The distance from the point on the diamond film penetrated by the beam to the surface of the CCD camera lens is 142 mm.

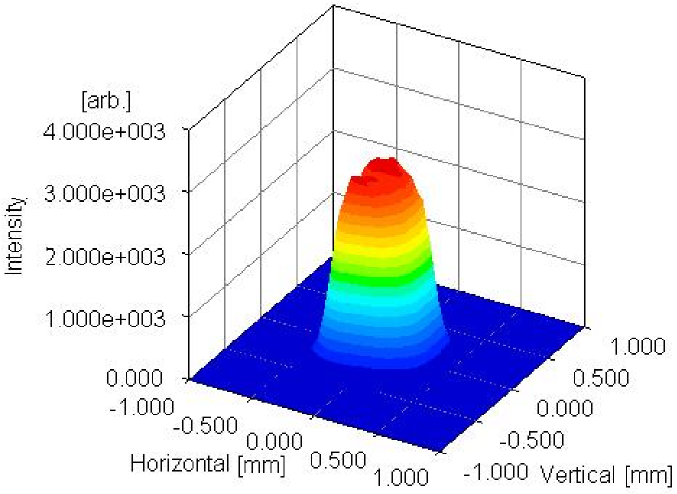

Fig.1 PL profile of CVD diamond (GAP:8mm)

Fig.1 shows a profile of PL that appeared at the point where the beam penetrated on the diamond film. The undulator gap was 8 mm. The energy of the first-order radiation is 11.9 keV. A PL spectrum has a intense peak at 739 nm that corresponds to the peak originating from Si impurity, and has a wideband structure extending from 450 nm to 700 nm.

There are two peaks in the vertical direction of the profile. It reflects the low energy components in the undulator raditaiton which are distributed on the upper and lower side of the beam axis.

From the image data, the PL intensities were estimated by the sum of the signals of all the image pixels captured by the CCD camera. By adjusting the undulator GAP to provide various flux and energy spectrum, it revealed that the PL intensities had a wide dynamic range with 10^4 of response to the absorbed dose per second in the diamond.