Competition between Cavity Response and Beam Focusing in Curved X-ray Cavity

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Unusual optical effects are reported for curved multi-plate x-ray cavities consisting of compound refractive lenses. X-ray (12 4 0) back diffraction from these monolithic silicon crystal devices clearly showed interference fringes due to cavity resonance through the compound refractive lenses (CRL). However, the expected focusing effect from the CRL was not observed. This beam compression was detected. Thus, a small sized parallel x-ray beam was produced. This beam compression is attritubed to the competition between the multiple back reflection in the crystal cavity and the focusing of the CRL, in addition to crystal absorption. The X-ray diffraction data were collected using synchrotron radiations at Spring-8 SP12U1 beam lines.

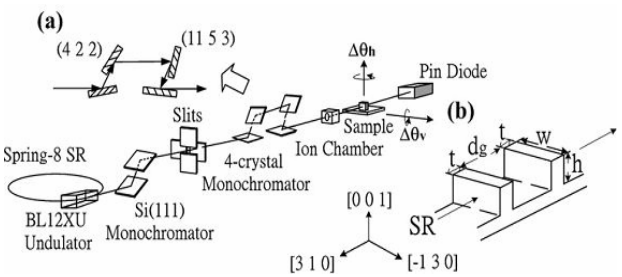

Figure 1. Experimental setup: (a) the side view of the four-crystal high-resolution monochromator; (b) the crystallographic orientation of the two-plate cavity. $\Delta\theta_v$ and $\Delta\theta_h$ are the vertical and horizontal tilting angles of the cavity crystal. The transmitted diffracted and the back-reflected beams are monitored by the pin diode and the ion chamber, respectively. SR stands for storage ring.
Physical Review Letter 94, 174801 (2005)

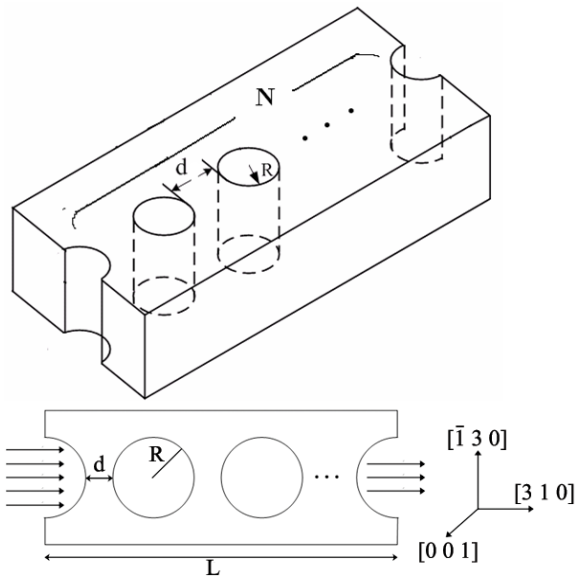

Figure 2. R=167.55μm, d=10μm, the numbers of the hole N=36, Total Length=360μm

We designed the CRL with the focus length of 1m and the focus size about 2μm.

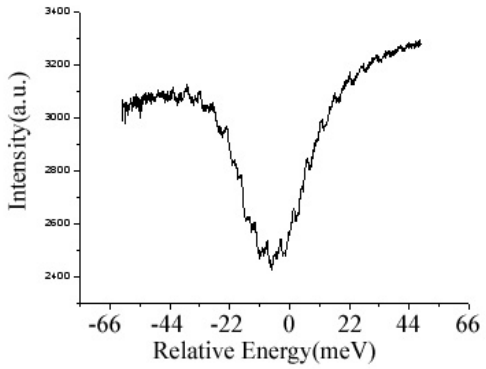

Figure 3. we can easily see the fringes of the cavity resonance for the CRL. The free spectral range is 5.4meV by calculating the formula $\Delta E=hc/2d$. It is agreement with our experimental analysis, 5.005meV.

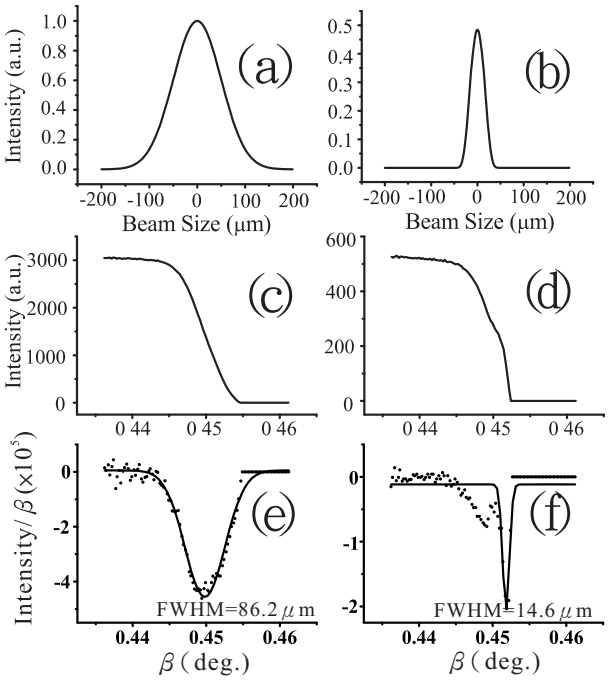

Figure 4. The source beam size is about 90μm. Behind the CRL, the beam size becomes 15~20μm but no focusing. By theoretical simulation, we consider a 100μm source beam pass through CRL. The beam size becomes 47μm and 28μm due to the linear absorption and diffraction respectively.