NANOTUBES AS WAVEGUIDE FOR X-RAY OPTICS

Yu-Jie Sun[1], Yao Cheng[1], Feng Wang[1], Jia-Ming Li[1, 2]

[1]Department of Physics
and
[1]Center for Atomic & Molecular Nanosciences
Tsinghua University, Beijing, 100084, China
[2]Institute of Physics, Chinese Academy of Sciences,
Beijing 100080, China

In this paper, carbon nanotubes (CNT) are considered to be the x-ray fiberoptics to control the propagation direction of x-rays, especially for the application of an array scanning x-ray microscope. Hollow glass fiber is a well-known commercial fiberoptic device for x-ray optical systems [1]. Recently, CNT has been theoretically demonstrated to channel nanoscale x-rays as well as nanoscale particle beams [2].

Two main effects inducing the intensity loss of x-rays in a bending nanotube are considered in our calculations. One is the absorption and the other is the penetration due mainly to frustrated total internal reflection (FTIR) as the incident angle is smaller than the critical angle. Soft x-rays in the water window are interested for the biological applications. Unfortunately, our calculations showed that the strong absorption prohibited this kind of CNT applications. On the other hand, x-rays of higher energy reduce the absorption but penetrate the CNT. Nanotube of other materials such as bismuth [3] or gold coated CNT have to be considered to reduce the penetration loss.

CNT with internal diameters φ of 30 nm and 50 nm were considered to channel x-rays of 500 eV and 1000 eV. Figure 1 is the schematic drawing of the CNT geometry applied in calculations with a bending angle from 0 to 5 degrees. Figures 2~5 are the calculated results. ABS Lines included loss effects of the absorption and the penetration from large incident angle without considering FTIR. We observed a significant increase of the penetration loss in the large-angle region of figures 4 and 5. Numbered Lines indicate the numbers of CNT layers. As the layer number increased, FTIR was reduced. Penetration and absorption of x-rays were calculated by ray tracing using the dielectric constant obtained directly from the electron distribution of CNT. We applied the WKB method to evaluate FTIR.

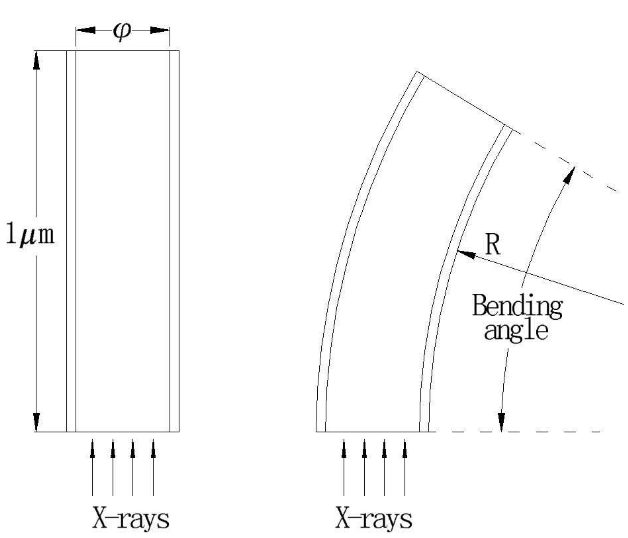

Figure 1: CNT geometry applied in calculations.

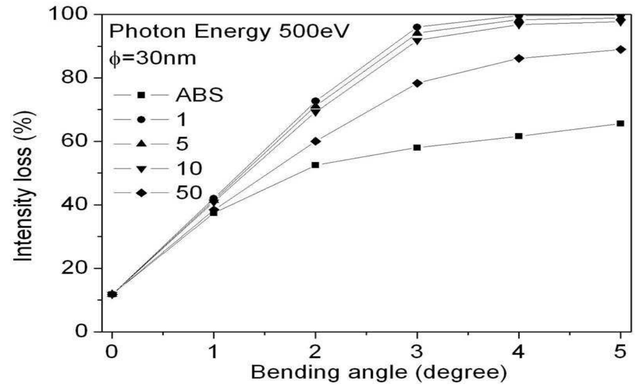

Figure 2: Intensity loss of 500 eV x-ray. CNT of 30 nm diameter was used in the calculation.

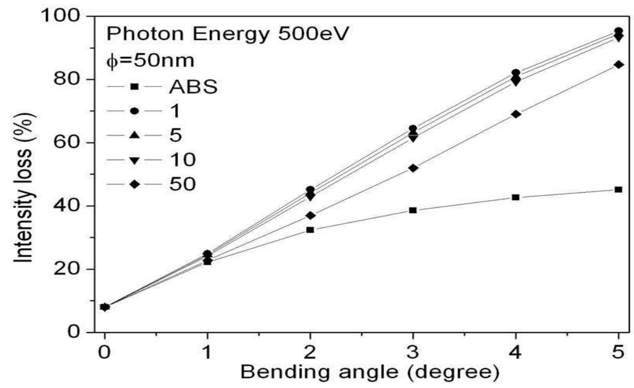

Figure 3: Intensity loss of 500 eV x-ray. CNT of 50 nm diameter was used in the calculation.

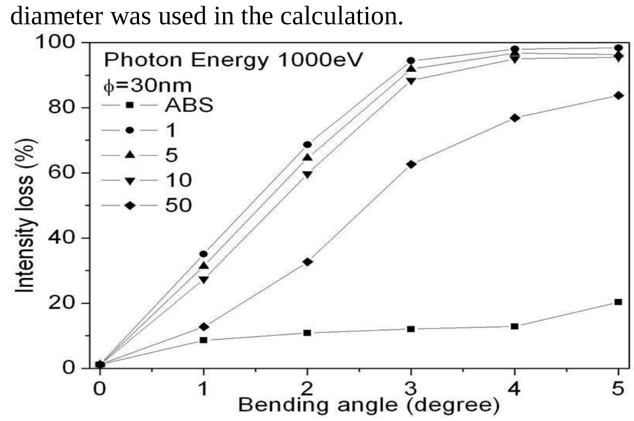

Figure 4: Intensity loss of 1000 eV x-ray. CNT of 30 nm diameter was used in the calculation.

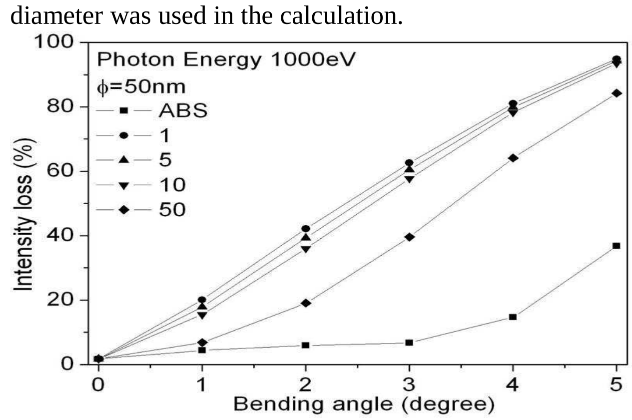

Figure 5: Intensity loss of 1000 eV x-ray. CNT of 50 nm diameter was used in the calculation..

References

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