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Supplementary Information

Bonding and Electronic States of Boron in Silicon Nanowires Characterized by Infrared Synchrotron Radiation Beam

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1. Properties and advantages of micro-FT-IR using IR-SR

The use of IR-SR (BL43IR) at SPring-8 in Japan affords several important enhancements to micro FT-IR.[1] Here we briefly describe its properties and advantages. IR-SR's most important property is its considerably higher brilliance than conventional IR light sources that employ thermal radiation. The data in Figure S1 shows that the brilliance of IR-SR is 10^2 times higher than general black body light. The details of calculations are shown elsewhere.[2] This

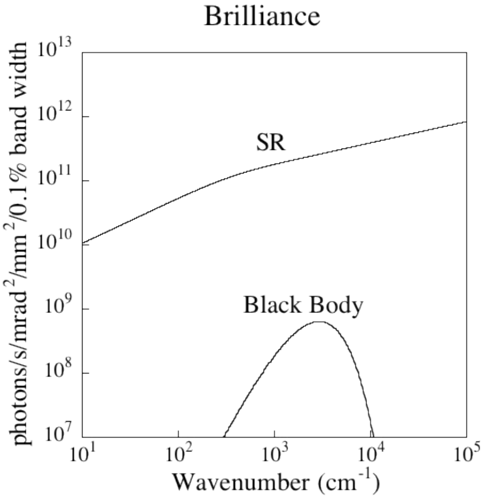

Figure S1. Brilliance of IR-SR. The data of a black body light in a typical infrared microscope is also shown.

allows the optical spectrum in even microscopic regions to be measured down to lower frequency regions through the cryostat's KRS-5 window.

The characterization of nanomaterials is often carried out using extremely small samples. This makes the ability to carry out characterization in microscopic regions more important. Furthermore, to be able to carefully characterize the physical properties of nanomaterials, it is important to carry out experiments at low temperatures. In this study, we used a Schwarzschild mirror with x8 magnification as shown in Figure S2. The working distance of this mirror is about 50 mm, making it possible to use a cryostat and finally realize micro-FT-IR measurements at low temperatures. Figure 3S shows beam profiles of micro-FT-IR using IR-SR and a conventional IR light source using thermal radiation in the mid-

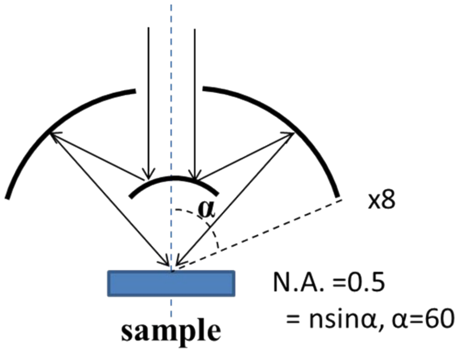

Figure S2. A schematic illustration of a Schwarzschild mirror.

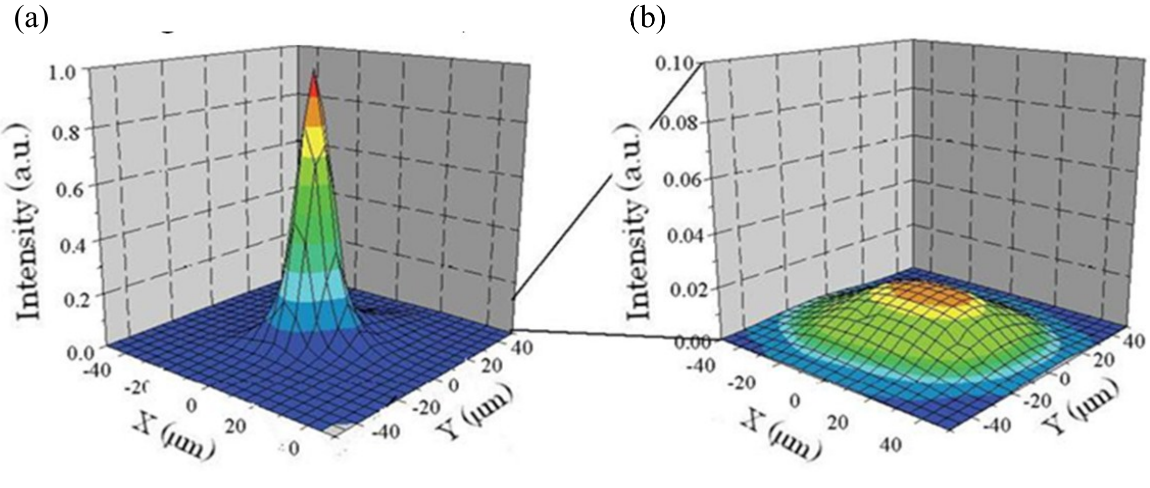

Figure S3. Beam profiles of (a) micro-FT-IR using IR-SR facility and (b) a conventional IR light source using thermal radiation at mid infrared region.

infrared region. The full width at half maximum of the beam size of the micro-FT-IR is significantly reduced to 8 x 6 μm, markedly narrower than that of a conventional IR light source using thermal radiation (63 x 43 μm). The IR-SR beam also has much greater brilliance than black body light, as mentioned above. It is thus possible to apply the micro-FT-IR technique to the characterization of nanomaterials by using IR-SR.

2. A proof of Fano resonance in B-doped SiNWs

The line shape of the Si optical phonon peaks due to the Fano effect is strongly affected by the excitation light wavelength during Raman measurements. To prove that the asymmetric broadening observed for B-doped SiNWs is due to the Fano effect, we checked its dependence on the excitation wavelength. Figure S4 shows the dependence of the Raman line shapes on the excitation wavelength. The optical phonon peak showed a large broadening to a higher wavenumber on increasing the excitation wavelength from 532 nm to 633 nm. In addition to this, the Si optical phonon peak observed at 633-nm excitation clearly showed antiresonance at low wavenumbers. These line shapes are characteristic of the Fanon effect, indicating conclusively that the asymmetric broadening is due to the Fano effect and that high concentrations of B atoms were doped in the SiNWs.

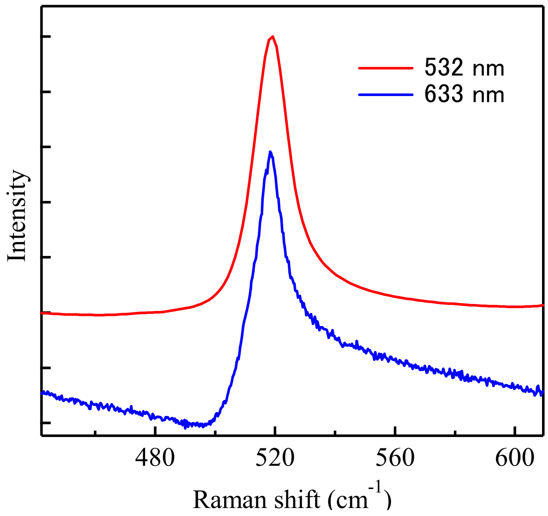

Figure S4. Dependence of the line shape of the Si optical phonon peaks on the excitation wavelength during Raman measurements.

References

1. T. Moriwaki et al.: Infrared Physics and Technology 51 (2008) 417-419.

2. Y. Ikemoto et al.: Optics Communications 285 (2012) 2212–2217.