Supplemental Material:Phase Controlled Homodyne Infrared Near-field Microscopy and Spectroscopy Reveal Inhomogeneity within and among Individual Boron Nitride Nanotubes

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Evaluation of spatial resolution

The spatial resolution of *a*NSOM can be evaluated in two complementary ways: by measurement of near-field scattering intensity as a function of tip-sample distance (Z-plot), and using a cross section from *a*NSOM image from a sharp feature on the sample. Figure S1 shows a Z-plot obtained with a tip approaching a gold substrate. It exhibits a vertical field localization of 10 nm, which indicates high spatial resolution. Figure S2 shows intensity variations of the near-field signal over a sharp feature from a BNNT. It gives smaller than 20 nm spatial resolution, which is the upper limit of spatial resolution of this method.

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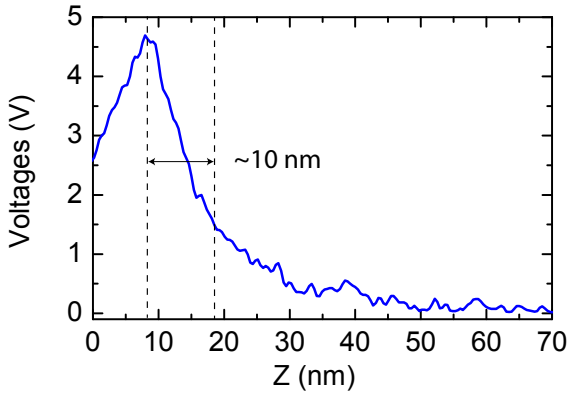

Figure S1: Tip-sample near-field approach curve (Z-plot) reveals the vertical field localization. Signal is recorded from the third harmonic of the lock-in demodulation.

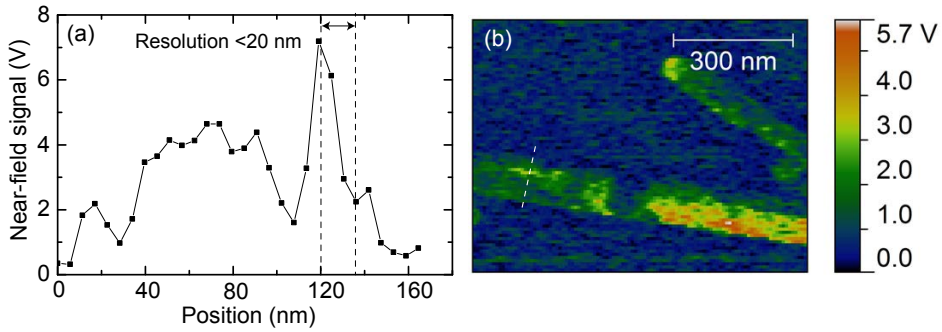

Figure S2: (a) A cross section on *a*NSOM image collected with a laser frequency at 1399 cm^{-1} gives sharp variation of intensity. (b) The location of the cross section from the *a*NSOM image.

In-phase homodyne *a*NSOM

Figure S3 shows a comparison between an in-phase homodyne and a $\pi/2$ phase homodyne *a*NSOM image. The in-phase homodyne *a*NSOM signal primarily reflects the real part of the near-field polarizability. As a result, the signal from gold substrate is much larger than the signal from BNNTs at in-phase homodyne. In contrast, $\pi/2$ phase homodyne suppresses signal from the gold substrate, and allows background free detection from vibrational resonances from BNNT at this wavelength.

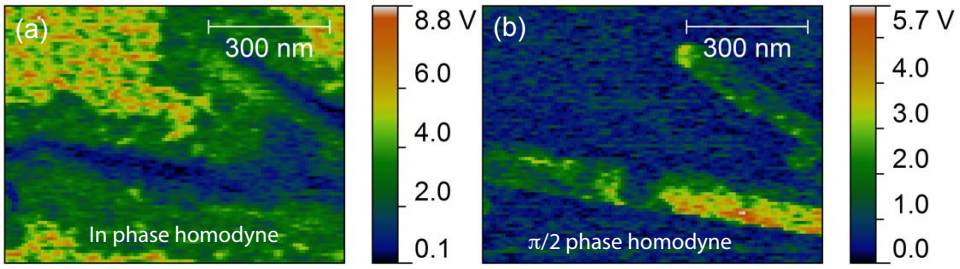

Figure S3: (a) An in-phase homodyne *a*NSOM image at 1401 cm^{-1}. (b) A $\pi/2$ phase homodyne image of the same area

*a*NSOM image of a bent nanotube

We have studied additional nanotubes in our *a*NSOM study. There is one BNNT that exhibits a bend (see Figure S4a). The corresponding *a*NSOM image at 1415 cm^{-1} shows that this tube not only has enhanced near-field absorption at its terminal ends but also gives a change in response in the vicinity of the bend.

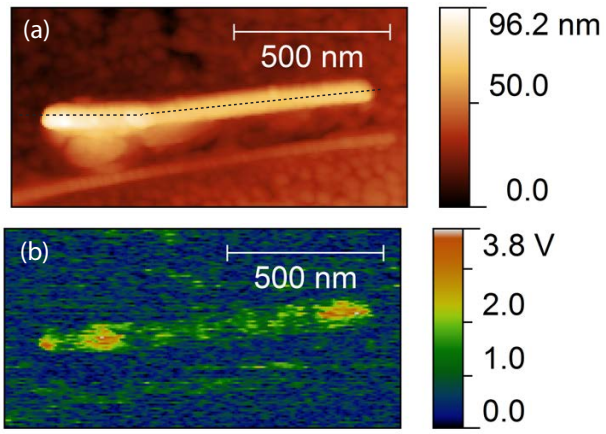

Figure S4: (a) AFM topography of another BNNT (b) *a*NSOM image of this BNNT at 1415 cm^{-1}