Near-field microscopy of thermally excited waves

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Abstract.

We demonstrate near-field microscopy of spontaneous surface waves with a sensitive near-field microscope, which does not utilize external illumination. Our "passive" near-field microscope is based on a home-made scattering-type scanning near-field optical microscope (s-SNOM), which is constructed by incorporating an atomic force microscope into a confocal microscope equipped with an ultra-highly infrared detector, named "charge sensitive infrared phototransistor" (CSIP, wavelength: 14.5 μm). In our s-SNOM, a sharp tungsten probe with a radius of 20 nm is vertically modulated at 10 Hz and spontaneous near-field signals are obtained after demodulating the signals at fundamental frequency. With the microscope, we achieve spontaneous evanescent waves from a room-temperature object with 5-μm pitch Au gratings deposited 100 nm on dielectric substrate. The spatial resolution now reaches 20 nm (λ/725). In this lecture, we show the microscope development, examples of signals, and detailed analyses for understanding the near-field signal origin. The distance dependence, the sample-size dependence, and the temperature dependence of the near-field signals confirm that the obtained signal should originate from thermally activated charge fluctuation strongly localized near the metal/dielectrics surfaces. We also demonstrate nano-thermometry by probing passive near-field signals on biased metal micro-patterns, which reveals local temperature distribution with nanoscale resolution. These results strongly suggest that our s-SNOM is very well suited for studying mesoscopic phenomena on biomolecules as well as hard materials.