Modulating near-field heat transfer using oxygen contaminated piezoelectric aluminum nitride nanomaterials

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We investigate the modulation of near-field heat transfer between piezoelectric aluminum nitride thin plates and nanospheres. Temperature-dependent infrared spectroscopic measurements showed soft phonon modes indicating a sharp change in the atomic structures of defect complexes in aluminum nitride at a transition temperature. The analysis of the measured infrared spectra showed a drastic change in the infrared dielectric properties upon switching between the observed defect complexes. By using the dielectric properties obtained from measurements, we demonstrate theoretically that the radiative heat transfer between aluminum nitride nanospheres can be dynamically modulated with a peak-to-peak value ranging from 0% to 40% of the maximum net heat transfer upon switching between the atomic structures of defect complexes. The high piezoelectric properties of aluminum nitride materials allow imitating the observed effect of thermal stresses by mechanical stresses resulting from the application of an external electric field.