A Resonance Tuning of Localized Phonon Polaritons on Hexagonal Boron Nitride

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Graduate optical metasurfaces have been used to control a wavefront of light in free space and in optical waveguides. However, a control of light on two-dimensional surface has been challenging because of the high optical power loss from metallic nanostructures. In recent years, we have chosen polar dielectrics as a metasurfaces platform because the polar dielectrics have a low optical power loss and a high coupling efficiency to the light from ionic crystals.

In this work, we propose metasurfaces platform made of two-dimensional hexagonal boron nitride (hBN). We have searched for a localized surface phonon resonance by designing the device using full wave simulation with the finite-difference time-domain method. We studied two different geometries; metal/dielectric multilayer boundary underneath and on hBN.

**Background**

- **Metasurfaces**
  - Sub-wavelength patterned layer
  - Providing spatially varying optical responses including phase, amplitude, polarization, and impedance of the light.

- **Polar dielectric metasurfaces**
  - Utilizing surface phonon polariton resonances (optical metal) instead of plasmonic resonances (metal)
  - Low optical power loss and a high coupling efficiency

- **Modeling thin film reflection**
  \[ R = \frac{n_r^2 - n_i^2}{n_r^2 + n_i^2} \]

- **Searching for phonon polaritonic resonances (FDTD)**

**Results**

- **Finite-difference time-domain (FDTD) simulation**
  - Without nanostructures

**Conclusions**

We investigated localized surface phonon polariton resonances in two different geometries; metal/dielectric multilayer boundary underneath and on hBN. Without a nano-gap, simulation results are consistent with known experimental results. With a nano-gap, multiple resonances exist which origine comes from Mie-type resonance conditions. We will perform further investigation of the resonances.
