Investigation of Surface Phonon Polariton Localization on Hexagonal Boron Nitride

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Introduction

Polar dielectrics have been chosen as a metasurfaces platform in recent years because the polar dielectrics have a low optical power loss and a high coupling efficiency to the light at the optical phonon band. We classified polar dielectrics into two groups, bulks and two-dimensional materials, depending on the evanescent field characters of surface waves of the light on polar dielectrics.

In this work, we chose hexagonal boron nitride (hBN) as a metasurfaces platform. We made two-dimensional hBN flakes by mechanical exfoliation and transferred hBN flake on the nanostructures. We have searched for a localized surface phonon polaritons on metal or dielectric boundary underneath hBN.

Background

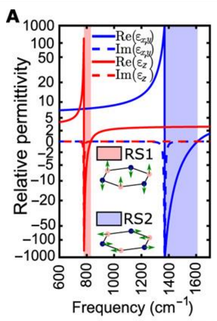
- **hBN (hexagonal boron nitride)**
  - Two different optical phonon modes

Out-of-plane In-plane

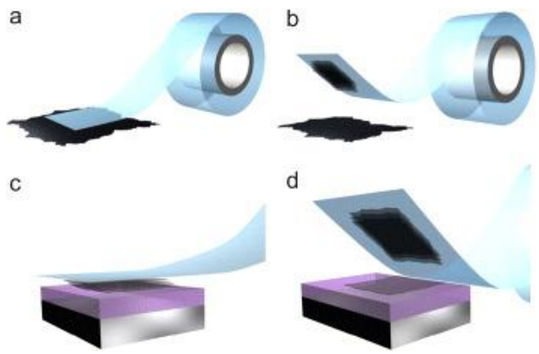
	Optical axis	Spatial axis	$\omega_{TO}(cm^{-1})$	$\omega_{LO}(cm^{-1})$	ε_0	ε_∞	$\gamma(cm^{-1})$
out-of-plane	c	z	1360	1614	6.90	4.90	7
in-plane	a and b	x and y	760	825	3.48	2.95	2

[2]

$$\varepsilon = \varepsilon_\infty \left(1 + \frac{\omega_{LO}^2 - \omega_{TO}^2}{\omega_{TO}^2 - \omega^2 - i\omega\gamma}\right)$$



- **Mechanical exfoliation**
  - Adhesive tape peeling

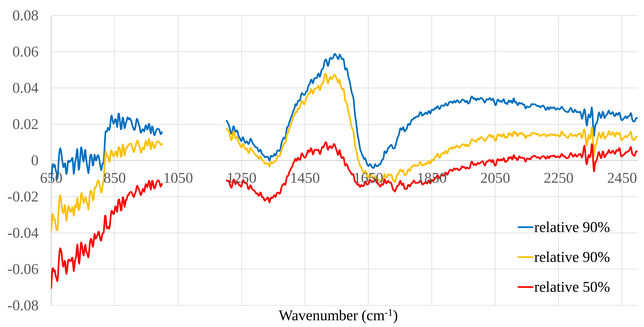


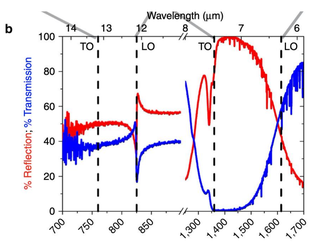
[3]

(a) Adhesive tape is pressed against a 2D crystal so that the top few layers are attached to the tape (b). (c) The tape with crystals of layered material is pressed against a surface of choice. (d) Upon peeling off, the bottom layer is left on the substrate.

Results

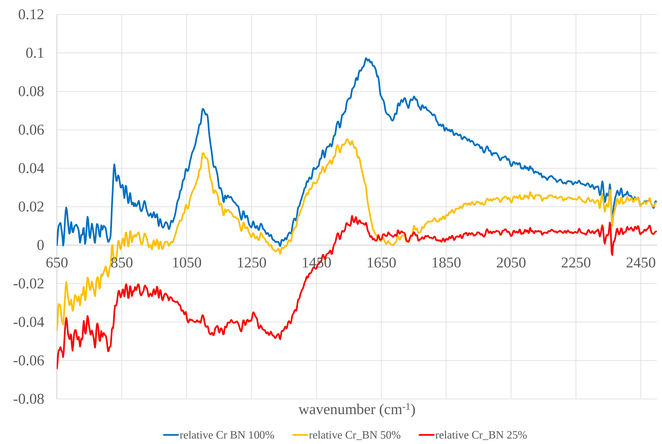
- **Relative reflection of BN**





[1]

- **Relative reflection of BN on Cr pattern**



Conclusions

We made two-dimensional hBN flakes by mechanical exfoliation and checked it by measuring the reflectance spectrum. We transferred hBN flakes on the nanostructures and searched for a localized phonon polaritons.
We will search stronger resonances and use crystal instead of powder.

References

[1] J. D. Caldwell et. al., "Sub-diffractional volume-confined polaritons in the natural hyperbolic material hexagonal boron nitride," Nat. Commun. 5, 5221 (2014)
[2] Michele Tamagnone et. al., "Ultra-confined mid-infrared resonant phonon polaritons in van der Waals nanostructures," SCIENCE ADVANCES (2018)
[3] K S Novoselov and A H Castro Neto 2012 *Phys. Scr.* 2012 014006, Two-dimensional crystals-based heterostructures: materials with tailored properties