Phononic SEIRA—enhancing light-molecule interactions via crystal lattice vibrations

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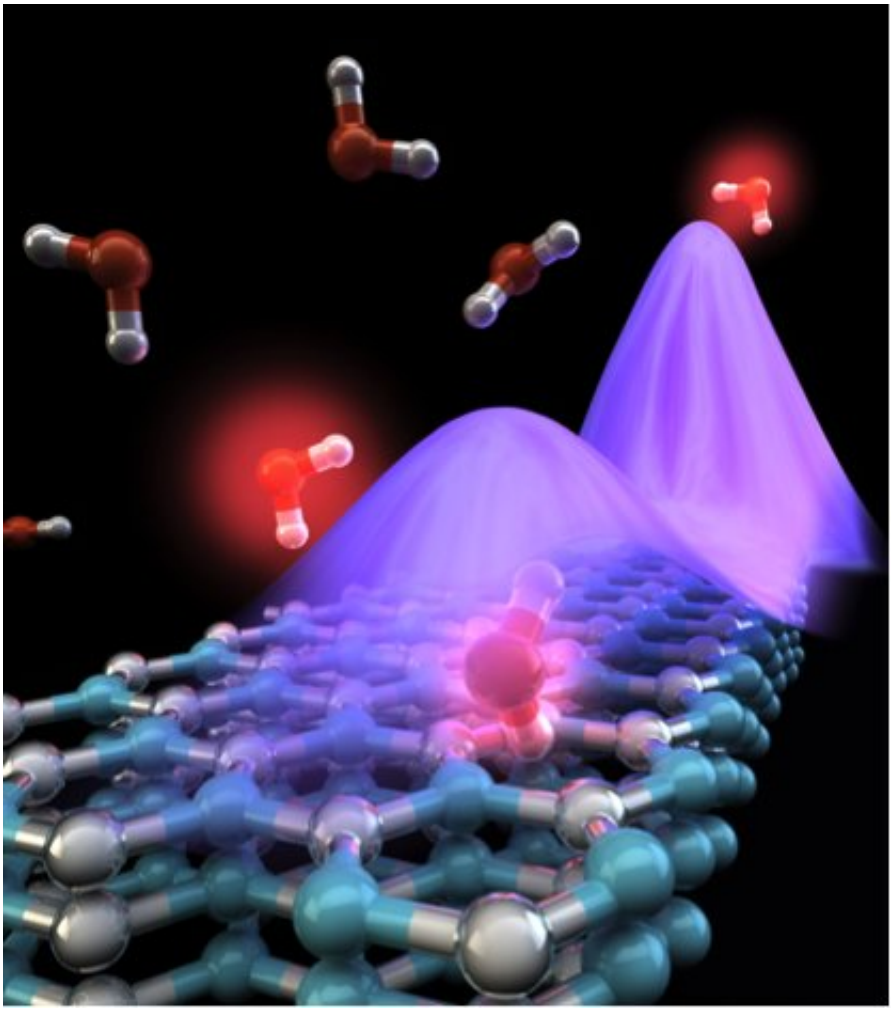

Illustration of the interaction between molecular vibrations and phonon polaritons in a boron nitride nanoresonator. Credit: Ella Maru Studio, Inc.

A study published in *Light: Science & Applications* opens new avenues for fundamental studies of vibrational strong coupling, as well as for the development of novel infrared sensors for chemical recognition of very small amounts of molecules. The interaction of light and matter at the nanoscale is a key element for many fundamental studies and technological applications, ranging from light harvesting to the detection of small amounts of molecules.

In recent decades, many strategies have been implemented to enhance nanoscale light-matter interactions. One approach is based on concentrating light with the help of propagating and localized surface plasmon polaritons, which are collective electron oscillations in metals or semiconductors that are coupled to light. These electromagnetic excitations can concentrate light into nanoscale spots, so-called hotspots. At mid-infrared frequencies, they enable the detection of tiny amounts of molecules. This method is called surface-enhanced infrared absorption (SEIRA) spectroscopy. However, typical mid-infrared plasmonic structures suffer from large losses and do not achieve ultimate light concentration.

An interesting but much less explored approach for enhancing nanoscale light-matter interaction is based on infrared-phononic materials, in which light couples to crystal lattice vibrations to form so-called phonon polaritons. "Phonon-polariton resonators offer much lower losses and field confinement than their mid-infrared plasmonic counterparts. For that reason, we decided to develop and apply infrared-phononic resonators to enhance the coupling of infrared light to molecular vibrations," says postdoc Marta Autore, first author of the paper.

In order to develop a method of phononic SEIRA, the researchers fabricated a set of ribbon arrays made of hexagonal-boron nitride (h-BN) flakes. By infrared transmission spectroscopy, they observed narrow phonon polariton resonances. Then, they deposited thin layers of

an organic molecule onto the ribbons. It led to a strong modification of the phonon polariton resonance, which could be used to detect ultra-small amounts of molecules (N

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