# ICFO researchers simplify the study of van der Waals materials

## ICFO researchers have presented in npj Nanophotonics an empirical method to optically characterize exfoliated flakes of low-dimensional van der Waals materials. This alternative approach is widely accessible and simple to implement in practice. This could accelerate material discovery and facilitate the design of many photonic and optoelectronic technologies that involve low-dimensional materials for molecular sensing, infrared spectroscopy, energy technologies, and thermal management.

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Low-dimensional van der Waals (vdW) materials -layered structures held together by weak van der Waals forces- stand at the forefront of scientific research in photonics, material science, electronics, spintronics, and other fields, mainly due to the highly unusual phenomena that these van der Waals interactions can cause. In particular, at infrared frequencies, scientists have uncovered several intriguing effects, such as anomalous refraction, where light travels backwards when refracted. These phenomena originate from

**phonon polaritons**: hybrid light-matter waves that form when a photon (a quantized vibration of light) and a phonon (a quantized vibration of the atomic lattice) become coupled together. Researchers studying these phonon polaritons have long faced an experimental limitation. On the one hand, the highest quality of vdW materials is achieved through mechanical exfoliation, a process that yields small flakes, only a few tens of micrometers in lateral dimensions. On the other hand, phonon polaritons occur at mid-infrared (mid-IR) frequencies, and light beams within this frequency range cover a large area when interacting with a sample, far exceeding the flakes' dimensions. Consequently, a mid-IR beam illuminates not only the flake but also a substantial portion of its surroundings, obscuring the very characteristics of the material under study and introducing significant challenges in their optical characterization with conventional methods (for instance, spectroscopic ellipsometry).

Overcoming this drawback has typically come at a cost of expensive instrumentation including tuneable lasers and near-field nano-imaging setups, which are highly sensitive to the external environment and can lead to poor data quality. In addition, previous approaches required extensive numerical modelling. Now, ICFO researchers, **Dr. Mitradeep Sarkar**, **Dr. Michael T. Enders**, **Dr. Mehrdad Shokooh-Saremi**, **Evgenia Klironomou**, **Dr. Hanan H. Sheinfux**, **ICREA Prof. Frank Koppens**, led by **Prof. Georgia Papadakis**, together with Istituto Italiano di Tecnologia and National Institute for Materials Science (Tsukuba, Japan), have introduced **a simple and accessible method to probe phonon polaritons in small flakes of vdW materials**.

The proposed technique, recently published in npj Nanophotonics, measures the frequency of light reflected from the sample and, from that, computes its **dielectric function**, which describes how light propagates through, reflects from, or is absorbed by a material and, consequently, is sensitive to phonon polaritons.

To validate their method, the researchers chose two widely used vdW materials: hBN and ?-MoO3. Through mechanical exfoliation, they created multiple flakes of varying thicknesses, whose reflectance spectra were measured using conventional far-field Fourier Transform Infrared micro-spectrometry. Using this **standard laboratory equipment**, the team could accurately determine the dielectric function, making the method significantly more **accessible** and **easier to implement** compared to previous approaches.

ï¿½Materials supporting phonon polaritons can enable strong light confinement
nd manipulation at the nanoscale, which is important for infrared nanophotonics, sensing,
nd spectroscopy,ï¿½ explains ICFO Prof. Georgia Papadakis, lead researcher of the study. ï
?½The benefit of our approach lies in its simplicity, making the characterization of low-dime
sional materials accessible in the majority of laboratories that possess a microscop
and a spectrometer, rather than expensive nano-imaging instrumentation. This could, in turn, **accelerate materials discovery**ï¿?

**Reference:**

Sarkar, M., Enders, M.T., Shokooh-Saremi, M. et al. Far-field extraction of the dielectric function of exfoliated flakes near phonon resonances. npj Nanophoton. 3, 11 (2026).
DOI: https://doi.org/10.1038/s44310-026-00106-8

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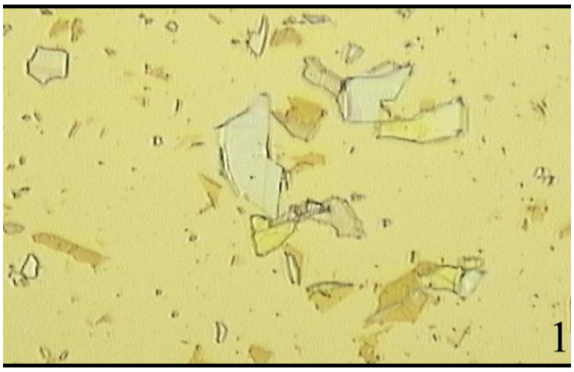

Microscope image of exfoliated hBN flakes on a gold substrate. Source: npj Nanophotonics.