SEMINAR SERIES

PHOTONICS INITIATIVE

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Polaritonic Insights from Near-field Nanoscopy:
Flat-Band Ultrastrong Coupling and Plasmons in Gold Monolayers

Abstract - Scattering-type scanning near-field optical microscopy (s-SNOM) and nanoscale Fourier-transform infrared (nano-FTIR) spectroscopy probe light–matter interactions at the nanoscale using the sharp tip an atomic force microscope (AFM) as an optical antenna. The illuminated tip generates a strongly confined near field that couples to local excitations in the sample, and the scattered light is recorded to reveal these interactions. These techniques enable the local excitation and detection of, for example, phonons, plasmons, and polaritons in both bulk and low-dimensional materials across a broad spectral range [1]. After a brief introduction to the technique, I will present recent studies on polariton mapping.

Using pump–probe nano-FTIR, we investigate the coupling between optical phonons in a thin SiC layer and surface plasmon polaritons (SPPs) in an InAs substrate. By tuning the SPP dispersion to align with the SiC phonon, we observe ultrastrong coupling with a mode splitting exceeding 20%. Owing to the flat SPP dispersion, this ultrastrong coupling extends over an unusual wide momentum range, realizing a flat-band ultrastrong coupling regime [2].

We further apply near-field nanoscopy to study a stable, quasi-freestanding gold monolayer (ML-Au) formed by intercalating gold atoms between graphene and a SiC substrate [3]. Via polariton interferometry, we obtain clear evidence of plasmon polaritons. From the experimental images, we extract the plasmon dispersion and model it with a two-dimensional Drude conductivity. The Drude weight is found to be roughly twice that of bulk gold, consistent with values obtained from DFT band-structure calculations, highlighting ML-Au as a promising platform for low-dimensional plasmonics and optoelectronic applications [4].

- Hillenbrand et al., *Nat. Rev. Matter.* **10**, 285 (2025)
- Vicentini et al., *Nat. Mater.* (2025) https://doi.org/10.1038/s41563-025-02412-6
- Forti et al., *Nat. Commun*. **11**, 2236 (2020)
- Bylinkin et al., *in preparation*

Bio - Rainer Hillenbrand is an Ikerbasque Research Professor and Nanooptics Group Leader at the nanoscience research center CIC nanoGUNE in San Sebastian (Basque Country, Spain), and a Joint Professor at the University of the Basque Country. He is also co-founder of the company neaspec GmbH (Germany), now part of attocube systems AG (Germany), which develops and manufactures near-field optical microscopes. From 1998 to 2007 he worked at the Max Planck Institute of Biochemisty (Martinsried, Germany), where he led the Nano-Photonics Research Group from 2003 to 2007. He obtained his PhD degree in physics from the Technical University of Munich in 2001.

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Date:
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Time:
11:00am – 12:00pm

Location:
ASRC Auditorium
85 Saint Nicholas Terrace
New York, NY 10031

Host:
Andrea Alù, Director, Photonics Initiative, ASRC, CUNY GC

Zoom Meeting ID 815 5135 5607 Passcode 226190

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