Crystalline gold flakes – a platform for extremely confined polaritons

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Since the seminal work by Jer-shing Huang, Bert Hecht and co-workers [1], crystalline flakes of noble metals are now finding increasing use in plasmonics. This is motivated in part by their lower propagation loss associated with Ohmic damping, but also by the potentially reduced scattering loss related to the atomic-scale flatness of these flakes [2]. The reduced propagation loss potentially opens up for explorations of nonlocal corrections [3], while the combination of two-dimensional materials (graphene) and metal flakes have also been suggested as a way to probe surface-response functions associated with the electrodynamic response of metallic flakes [4] or even the electrodynamics of correlated matter [5].

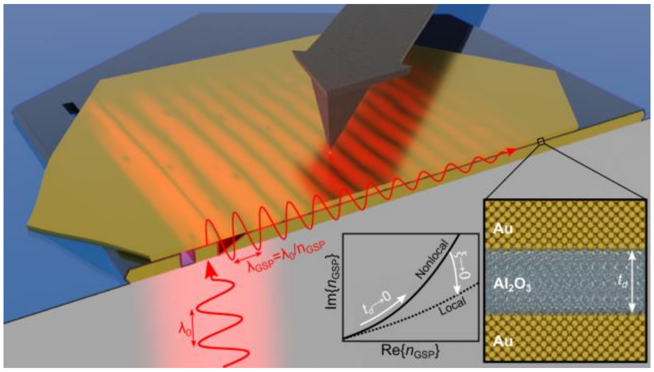

Fig. 1 Schematic illustration of the SNOM exploration of gap-plasmon propagation in a metal-insulator-metal structured comprised by a sandwich of two metal flakes separated by an oxide layer [7].

This talk will review recent examples where scanning near-field optical microscopy (SNOM) is used to explore polariton propagation either associated with the plasmon response of the metallic flakes themselves [3] or because of the polariton response of two-dimensional materials on top of the flakes, i.e., so-called image polaritons [6].

As a first example of intriguing plasmon propagation, metal-insulator-metal waveguide structures with dielectric gaps down to nominally 2 nanometers have been realized by separating two gold flakes by ultrathin dielectric layers (Fig. 1), thus potentially promoting quantum nonlocal aspects of the plasmon response [7]. Here, the low propagation loss of the flake-supported plasmons is critical for Ohmic damping not to dominate over any possible nonlocal corrections.

As another example, the very same flakes have been exploited as mirrors for polaritons in two-dimensional van der Waals materials placed almost immediately on top of these flakes, e.g., phonon polaritons in hexagonal boron nitride (h-BN) [5] or Molybdenum Trioxide (α-MoO3) [6]. In both cases, the low reduced scattering loss is key to the exploration and visualization of polariton propagation. Here, the flakes literately work as ideal mirrors, thus supporting exceedingly long propagation of the image polaritons with many oscillations of the polaritons immediately resolvable in SNOM explorations.

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