Soutenance de thèse

Tao WANG

Institut des Sciences Moléculaires d'Orsay (ISMO), Orsay

" Electrical excitation of surface plasmons with a scanning tunneling microscope "

For the first time, using a equipment combining a scanning tunneling microscope (STM) and an inverted optical microscope, we excite and directly image STM-excited broadband propagating surface plasmons on a thin gold film. The STM-excited propagating surface plasmons have been imaged both in real space and Fourier space by leakage radiation microscopy. Broadband localized surface plasmons due to the tip-gold film coupled plasmon resonance have also been detected. Quantitatively, we compare the intensities of STM-excited propagating and localized surface plasmons obtained with different STM tips. We find that the intensity of each plasmon mode can be selectively varied by changing the STM tip shape or material composition. A silver tip produces a high intensity of localized surface plasmons whereas a sharp (radius < 100 nm) tungsten tip produces mainly propagating surface plasmons.

We have investigated the coherence of STM-excited propagating surface plasmons by performing experiments on a 200 nm thick (opaque) gold film punctured by pairs of nanoholes. This work is analogous to Young's double-slit experiment, and shows that STM-excited propagating surface plasmons have a coherence length of 4.7±0.5 µm. This coherent length is very close to the value 3.7±1.2 µm expected from the spectrum, which indicates that the spectrum broadening of STM-excited surface plasmons is homogeneous.

We have also studied the in-plane and radiative scattering of STM-excited propagating surface plasmons by gold nanoparticles deposited on a 50 nm thick gold film. In the Fourier space images, interference fringes are observed in the forbidden light region. This interference occurs between STM-excited localized surface plasmons (radiating at large angles from the tip position) and the radiative scattering by the gold nanoparticle of STM-excited propagating surface plasmons. This indicates that STM-excited localized and propagating surface plasmons are different components of the same single plasmon produced by inelastic electron tunneling with the STM tip.

These results not only broaden the understanding about the excitation process of STM-excited surface plasmons but also offer interesting perspectives for the connection between nanoelectronics and nanophotonics.

Keywords:
STM, surface plasmons, coherence, interference, scattering

ATTENTION JOUR ET HEURE INHABITUELS

Mercredi 18 juillet 2012 à 10h30

Bât 210 – Amphi 1 (2ème étage)

Université Paris-Sud, 91405 Orsay Cedex

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