Tip-enhanced Raman spectroscopy (TERS), which is based on a plasmonic scanning probe tip, is an essential technique that allows nano-scale analysis of molecules. In particular, gap-mode TERS configuration allows access to ultra-high sensitive characterization and spatial resolution down to the single molecular level. To further improve the spatial resolution, control and understanding of the plasmonic property of the tip is indispensable. Here, I investigate the plasmonic interaction in the gap of a metallic nano tip and a thin film system using finite-difference time-domain (FDTD) method. The optical properties of the excited localized surface plasmon at the metallic gap are elucidated by changing the thickness of the thin film. The localized surface plasmon at the tip is hybridized with a continuum of surface plasmon on the film, which exhibits the tunable resonance energy of the localized surface plasmon at the gap according to the film thickness. Field enhancement confined at the gap under the plasmon resonance condition is discussed with respect to sensitivity and resolution.
Plasmonic Interaction at the Gap in a Metallic Nano Tip and a Thin Film System

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Raman Nanoscopy

Provides us with a significant color-image of molecules at the nano-scale resolution\textsuperscript{1}. Tip-enhanced Raman spectroscopy (TERS) — based on a plasmonic scanning probe tip —, allows nano-scale analysis of molecules. \textsuperscript{1} T. Yano et al., Nature Photon., 3, 473 (2009)

Purpose

To improve spatial resolution and sensitivity down to single molecular level by introducing a metallic thin film in order to create a nano-gap.

Gap-mode tip-enhanced Raman spectroscopy (TERS)

Scattering (a.u.)

0 60 20 40 60 80 100 120 140 160 180 200 220 240 260 280 300 320 340 360 380 400 420 440 460 480 500 520 540 560 580 600 620 640 660 680 700 720 740 760 780 800 820 840 860 880 900 920 940 960 980 1000 1020 1040 1060 1080 1100 1120 1140 1160 1180 1200

Wavelength [nm]

Scattering (a.u.)

0 60 20 40 60 80 100 120 140 160 180 200 220 240 260 280 300 320 340 360 380 400 420 440 460 480 500 520 540 560 580 600 620 640 660 680 700 720 740 760 780 800 820 840 860 880 900 920 940 960 980 1000 1020 1040 1060 1080 1100 1120 1140 1160 1180 1200

Wavelength [nm]

Tunable plasmon resonance in the nanoparticle-film system is observed, although surface plasmon on a film is excited where the surface plasmon is theoretically not coupled to the incident light.

Conclusion

- Plasmonic property at the tip-film gap is obtained by the FDTD analysis.
- The plasmonic property at the gap is tuned by the film thickness.
- The large field enhancement can be achieved in a wide-range wavelength.

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