Extreme Nanophotonics with Ultraflat Metals and Graphene

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Abstract

Plasmonic devices can beat the diffraction limit and confine electromagnetic waves into cavities as narrow as 1 nm. Precise high-throughput fabrication of such extreme nanophotonic structures is challenging with even most advanced electron-beam lithography tools. I will present unconventional approaches to produce sub-nanometer gaps.

Template stripping [1] has enabled rapid production of atomically smooth patterned metals and ultrasharp tips. In this process, instead of directly patterning metal films, which are difficult to plasma-etch, we engineer inverse patterns in a silicon wafer. After metal deposition and peeling, ultrasmooth patterns in the silicon wafer are replicated onto metal films, which have been used for near-field imaging, biosensing, and graphene plasmonics [2].

Atomic Layer Deposition (ALD) has enabled precise fabrication of both horizontal and vertical sub-nanometer metal-insulator-metal cavities to investigate extreme light confinement. I will discuss lithographic patterning applications of ALD - atomic layer lithography. We have demonstrated wafer-scale production of centimeter-long and sub-10-nm wide gaps in various metals for mid-infrared spectroscopic sensing, optical trapping [3], and waveguide-integrated plasmonic sensors.

References

[1] P. Nagpal, N. C. Lindquist, S.-H. Oh, D. J. Norris, ***Science*** (2009) 325, 594.

[2] I.-H. Lee, D. Yoo, Ph. Avouris, T. Low, S.-H. Oh. Graphene acoustic plasmon resonator for ultrasensitive infrared spectroscopy. ***Nature Nanotechnology*** (2019) 14-313.

[3] D. Yoo, et al. Low-power optical trapping of nanoparticles and proteins. ***Nano Lett.*** (2018) *18*, 3637.