A Dry-on, Dry-off, Long Wavelength Photoresist for NanoPlasmonic Field Metrology and Lithography

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Surface Plasmon Polaritons (SPPs) are useful in lithography, nanoscale optics, biosensing, and optical computing because of the interplay of four universal characteristics, which can be defined in terms of separate length scales: the SPP wavelength (λ_{spp}), the propagation length (λ_x), the penetration depth into the metal (λ_m), and the penetration depth into the dielectric (λ_d).[1] Lithographic applications require a small λ_{spp} to produce small features. In biosensor and nanoscale optics, λ_d controls the sensing volume. In optical computing applications, λ_x determines the distance that information can be carried along a surface without attenuation. Unfortunately, there is a known tradeoff: λ_x, λ_m, and λ_d typically become worse as λ_{spp} gets smaller.[1] This leads to a separation between the wavelengths of light used in plasmonic lithography (typically <400 nm) versus those used in other plasmonics applications. The potentially large field enhancement factors that make plasmonic devices such attractive candidates for biosensing are only realized in the red portion of the visible spectrum.[2]

Measuring the details of the fields produced by plasmonic structures is essential to understanding their performance. AFM measurements of resist exposed in the near-field by plasmons have been used at UV wavelengths.[3] This method has not been used to measure plasmonic fields in the visible region because standard photoresists are not sensitive at these longer wavelengths.

We have developed a negative tone photoresist that operates over a broad range of wavelengths across the visible spectrum, that may be useful for quantifying the field enhancement around plasmonic devices resonant in the visible. It will also find application in lithographic techniques that make use of the large local field enhancements that plasmonic devices can produce.

[1] W. Barnes, J. Opt. A.: Pure Appl. Opt. S87-S93 **8** (2006).
[2] Z. Liu, A. Boltasseva, R. H. Pederson, R. Bakker, A.V. Kildishev, V. P. Drachev, V. M. Shalaev, Metamaterials 45-51 **2** (2008).
[3] A. Sundaramurthy, G. S. Kino, P. J. Schuck, N.R. Conley, D. P. Fromm, and W.E. Moerner, Nano Lett. 355-360 **6(3)** (2006).

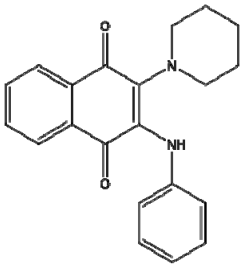

Figure 1. . Parent structure of the synthesized aryldiaminonaphthoquinones (PNQ): TPNQ = 4-methyl-PNQ. Other derivatives made were 4-MeO, 4-Br, 4-CO_2H, 4-NO_2, 3-OH, and 2-Me, respectively.

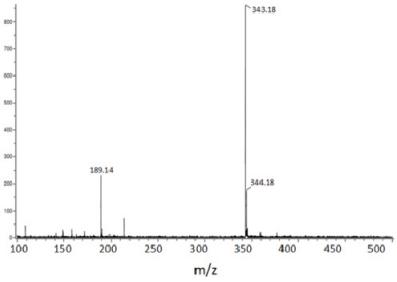

Figure 2. Mass Spectrograph of TPNQ thin film exposed to broadband visible irradiation. TPNQ m/z=347. The major product after exposure m/z=343.

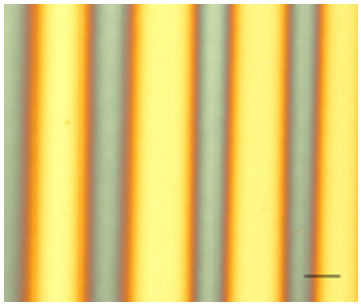

Figure 3. Optical micrograph of TPNQ thin film (100 nm) exposed to light of λ>500 nm to form a negative tone image. Scale bar=30 μm.

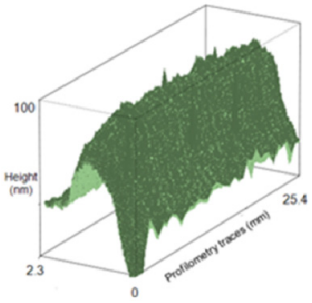

Figure 4. Sequential profilometry traces of evaporated TPNQ. Film thickness at the "ridge line" could be controlled to +/- 5 nm over 25mm.