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

P. T. Carmichael, J. A. Liddle
Center for Nanoscale Science and Technology, National Institute of Standards and Technology, Gaithersburg, Maryland 20899, USA
J. R. Strahan, C. G. Willson
Department of Chemistry,The University of Texas at Austin, Austin, Texas 78712

Surface Plasmon Polaritons (SPPs) can have much shorter wavelengths than the free space light used to initiate their propagation. They are known to scatter from small (<10 nm) surface objects, reflect at surface features such as grooves, interfere with one another, and can dwell differentially in one surface layer over another. Unfortunately, there are few tools available for imaging this behavior at high resolution. One approach for observing SPPs is to apply a photoresist to the surface and then image the cured film[1]. However, most commercially available photoresists only respond to radiation of $\lambda < 450$ nm, while the resonance wavelength of many types of plasmonic devices is much longer. Furthermore, the process of spin-coating and developing a resist may be difficult or impossible to perform with delicate or topologically unique samples.

A better alternative would be to use a specifically designed photoresist that was solvent-less, responded to light across the visible spectrum, and could be conformally and thinly (<20 nm) coated on the plasmonic surface so that it perturbed the field as little as possible. To this end, we have synthesized and investigated a series of dye molecules that can be evaporated to form thin films. The candidate molecules are all aryldiaminonaphthoquinone analogues of 2p-toluidino-3-piperidino-1,4-naphthoquinone (TPNQ). Noach et. al. showed that light from an AFM cantilever diode (670 nm) could induce negative tone pattern formation in thin films of TPNQ upon heating[2]. Here, to our knowledge, we show the first images obtained from patterning this material with visible light. Initial results show that TPNQ forms 100 nm thick films that are free from pinholes, are negative-tone upon irradiation with both ultraviolet and visible (>500 nm) light, are positive-tone with development in aqueous base, and can be developed at 150 °C in less than five minutes.

---

[1] Z. Liu, Y. Wang, J. Yao. H. Lee, W. Srituravanich, X. Zhang, Nano Letters, **9** (1), 462-466 (2009).
[2] S. Noach, M. Manevic, N. P. Eisenberg, and E. P. Fokin, Nanotechnology **16**, 775 (2005).

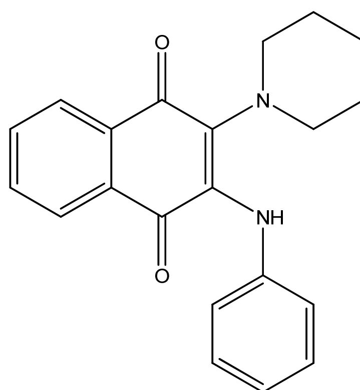

Fig 1 : Parent structure of the synthesized aryldiaminonaphthoquinones (PNQ) : Derivatives differed in their ortho-, meta-, or para- substituents along the aniline ring. TPNQ = 4-methyl-PNQ. Other derivatives made were 4-MeO, 4-Br, 4-CO_2H, 4-NO_2, 3-OH, and 2-Me, respectively.

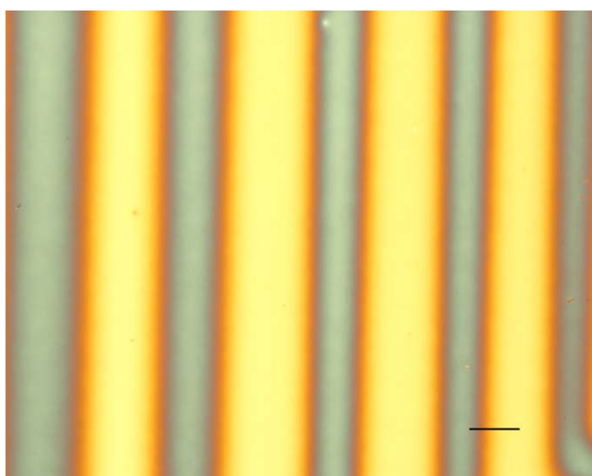

Fig 2 : Optical micrograph of patterned TPNQ: TPNQ was evaporated onto a silicon wafer to a thickness of ~100 nm and then exposed through a chrome on glass mask to broadband visible radiation (λ>500 nm) from a filtered incandescent bulb. The exposed resist was baked for 5 minutes on a hotplate to produce the negative tone image shown. Scale bar=30 μm.