Flexible PDMS Support Layers for the Evanescent Characterization of Near-Field Lithography Systems

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Near-field imaging systems have generated much interest over the last decade since the discovery that left-handed materials (i.e. materials with negative permittivity and permeability) can act as 'superlenses', capable of enhancing evanescent modes.[1] Much theoretical work was presented showing vastly improved resolution beyond the diffraction limit,[2] with only a small number of experimental examples given to support this hypothesis.[3] To date, a complete validation of modeled predictions against experimental results is still lacking from the literature.

One of the reasons for this lack of experimental data is that such demonstrations are extremely difficult to perform. Intimate contact between mask, lens and resist is required, since near-field image quality degrades rapidly as the distance between components increases. However, forced contact between rigid structures leads to accelerated wear and can cause breakages.[4] Furthermore, numerous exposures of objects with varying spatial periods are usually required to fully characterize a system.

To overcome the challenges posed by intimate contact, we propose the use of a flexible PDMS membrane beneath the superlens resist layer, shown in fig. 1. The PDMS absorbs strain caused by dust particles and other surface structures trapped between rigid components, thus preventing cracks and chips from appearing. The flexible membrane also allows enough force to be exerted on the mask, lens and resist components to ensure intimate contact and guarantee good near-field exposure, as illustrated in fig. 2. Once reliable contact is achieved, experimental characterization is performed based on evanescent intensity patterns captured in partially exposed resist. This provides data points over a range of spatial frequencies (fig. 3) that facilitate validation with analytical models.

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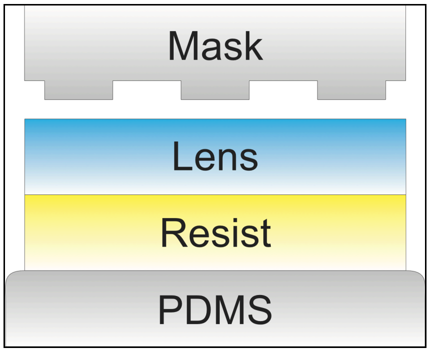
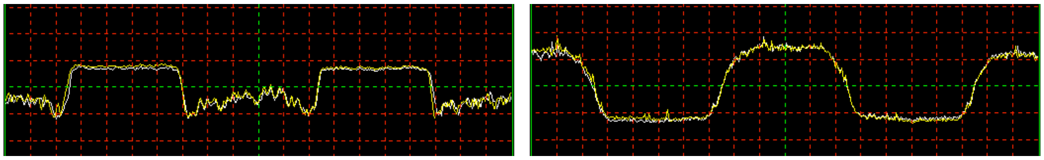


Figure 1: Superlens Assembly: A tungsten mask is positioned above a PVA|Ag|PVA superlens and a resist stack, composed of AZ 1518 resist and Barli II anti-reflective coating. Force is applied from above and below to ensure intimate contact. A PDMS substrate absorbs strain, protecting the mask and lens.



(a) with PDMS *(b) without PDMS*

Figure 2: AFM Line Profiles of Partially Exposed Photoresist: Intimate contact during the exposure step leads to resist profiles that have flat peaks and upwardly-curved troughs (left), characteristic of evanescent modes that concentrate around the edges of the mask features. Conversely, a 60 nm gap between mask and resist (right) leads to profiles with sloped peaks and rounded edges. Horizontal scale is 1 μm/division, vertical scale is 10 nm / division.

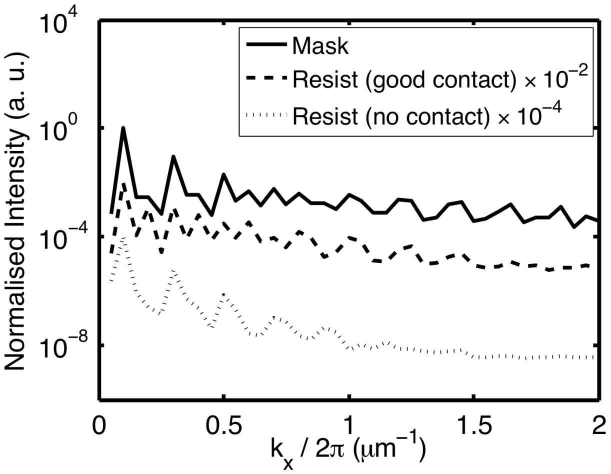


Figure 3: Spectral Content: Spatial frequency spectra of the line profiles shown in fig. 2 can be compared to analytical data, facilitating model validation. The experimental data confirm transmission of high-spatial frequency features from the mask (solid line) to the resist is better when mask and lens are in intimate contact (dashed line) than when the components are separated (dotted line).