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UV LITHOGRAPHY PROCESS FOR ULTRA-THICK HIGH ASPECT-RATIO SU-8 MICROSTRUCTURES

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ABSTRACT

Photolithographic processes are the corner stone of microfabrication. Resist patterning is therefore crucial to the development of many microdevices. By using a thick photoresist, MEMS designers can often use the polymer itself as the structural material for mechanical, optical, and fluidic devices. Therefore, a great deal of research has been performed by the MEMS industry to develop resist processing that can yield polymeric materials with aspect-ratios high enough to be used as for rigid mechanical systems. Currently, the standard thick resist used by MEMS engineers to develop microdevices using ultraviolet (UV) lithography is EPON SU-8 negative photoresist.

SU-8 is commonly used to expose patterns up to 1500 μm deep using either optical [1] or deep X-ray [2,3] lithography. Recent publications show the ability to expose 1 mm tall isolated SU-8 structures with aspect ratios exceeding 10:1 [4,5] and 1.5 mm structures with 5:1 aspect ratios in the pattern [6]. Dentinger [7] has recently shown aspect ratios approaching 50:1 for trenches in 100 μm of exposed resist and similar aspect ratios for complex patterned structures in 700 μm of resist.

Optimization of SU-8 resist processing has lead researchers in many directions. The use of optical filters [8,14] to eliminate low frequency light from the exposure has demonstrated higher process control and allowed for the production of high aspect ratios. Chuang [9] showed that adding Glycerin between the mask and substrate in contact lithographic systems greatly improved the pattern transfer by reducing unwanted diffraction effects. Finally, some have taken to modifying the resist chemistry [10] to improve the resist process. Each of these optimization techniques performed separately have demonstrated significant improvements in the production of SU-8 structures. By properly combining these techniques, great strides in SU-8 processing can be achieved. However, this work focuses on processing that can be done easily without special adjustment of the ultraviolet lithographic contact aligner or the resist. Instead, we focus on what can be achieved with any common contact aligner in any MEMS laboratory.

We present a simple SU-8 optical lithography process that yields aspect-ratios of 40:1 in isolated open field structures of thickness between 1 and 1.5 mm without any modifications of the resist chemistry or changes in light spectrum applied from a standard broadband UV source. A complete discussion of resist coating, baking, and exposure parameters will be presented. Resist development will be examined and some suggestions will be provided on how to better develop ultra thick SU-8 films. The process described uses Micro-Chem's SU-8 100 with no chemical additives and attempts to follow the protocol of traditional optical lithographic processing.

FIGURES AND TABLES

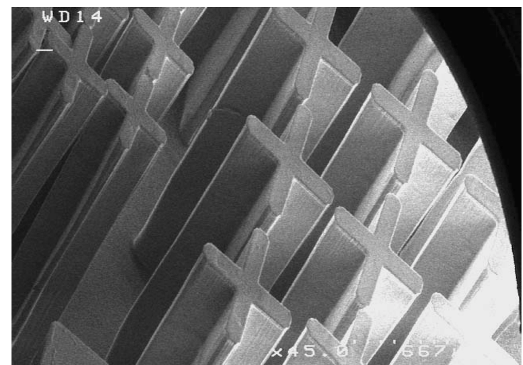

Figure 1 1500 μm tall field of crosses. Crosses shown are 35, and 45 μm in width.

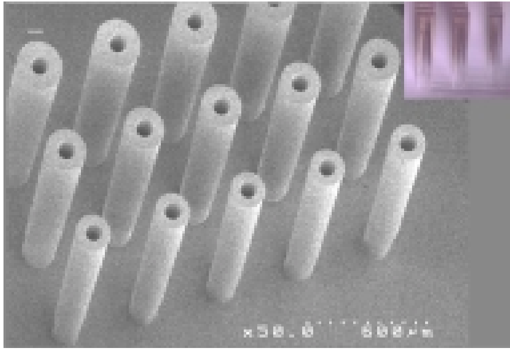

Figure 2 1150 μm tall Cylinders. Cylinder wall width of bottom row is 50 μm. The picture in the corner is an optical image showing that the cylinders are indeed developed through to the base.

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