Double patterning technology: process simulation and fabrication of optical elements

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Double patterning is an important technique for the improvement of spatial resolution of fabricated patterns. The technique is being adopted by major semiconductor companies for the production of chips. This method is especially attractive for fabrication of diffractive optical elements, where the topological elements are mostly repetitive. In this paper, we describe the simulation of dry etch and film deposition to study and optimize the vertical profile of fabricated patterns in double patterning; optical polarizers with a feature size 45 nm and a high aspect ratio were fabricated using Ir and Al layers.

A variably shaped electron beam lithography system was used for the fabrication of the initial resist pattern. Next, the Ir layer was deposited over the resist isotropically. This metal offers suitable properties necessary for a working layer in optical filters for short UV range. The pattern was then etched mostly anysotropically so that the top of the deposited layer was etched down to the resist. After resist removal, a pattern with doubled spatial frequency compared to the resist pattern was fabricated in the Ir layer. In addition, various optical elements for visible range made in Al are presented.

A software called TRAVIT was further developed in order to support the simulation of multiple consecutive technological steps. The software can model complex processes involving the combination of dry etch, film deposition, and electroplating. Variable vertical resist profiles and resist trim processes were used in order to optimize the process. For a specific resist profile, etch and deposition characteristics were varied to study their impact on the resulting vertical profile of the metal layers.

A good agreement of simulation results with fabricated patterns was found.

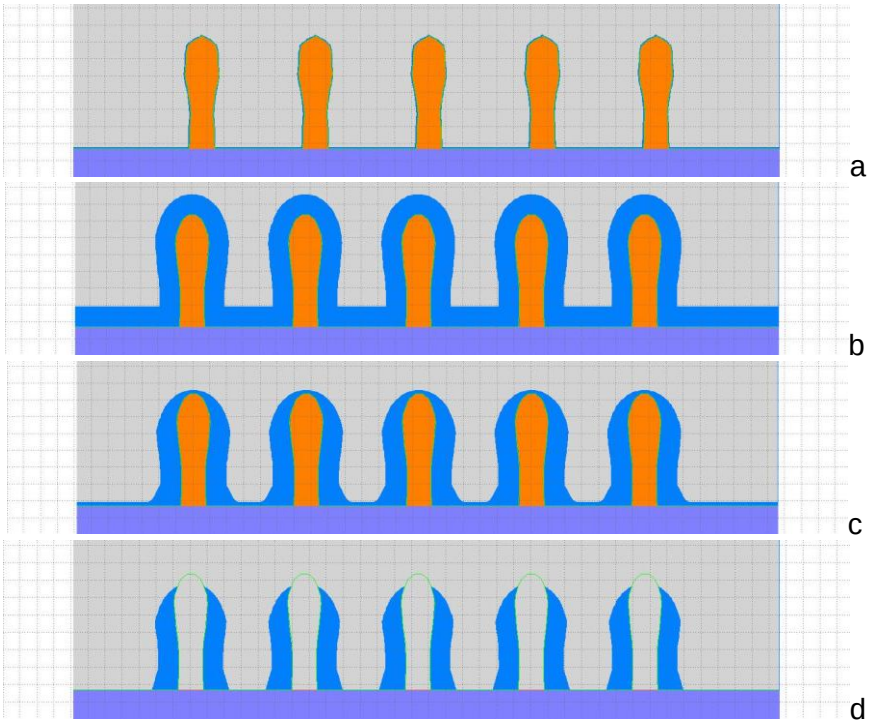

Figure 1. Simulated profiles in double patterning of optical elements. a) resist profile after EBL, b) deposited Ir layer, c) mostly anisotropic etch, d) final pattern with doubled pitch

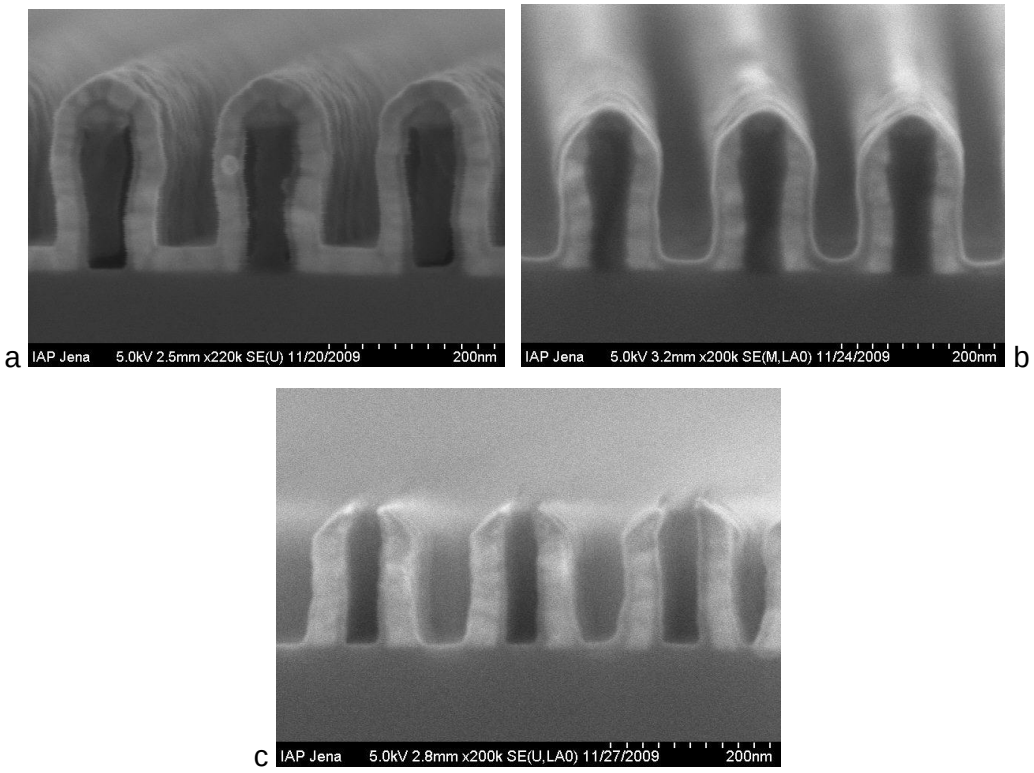

Figure 2. SEM images of a pattern of optical filters for deep UV range fabricated using Ir. 45 nm feature sizes with high aspect ratio made using double patterning.