Imprint-direct etch process using single layer non-Si-contained UV resist for NIL mold duplication

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Non-semiconductor applications demand nanoimprint lithography (NIL) to demonstrate very low cost of production, in order to make these applications market-feasible. Considering every aspect of cost, mask or mold is one of significant parts of overall budget of implementing NIL into production. In addition to other cost reduction measures, a very efficient way to further reduce cost is to use duplicated mold for wafer production and save usage of master mold for making duplicated molds only. This paper presents an imprint-direct etch process using single layer non-Si-contained UV resist for NIL mold duplication. The mold duplication process has fewest processing steps, thus, potentially achieve very high duplicated pattern fidelity and very low duplication defect density.

Fig 1a illustrates the process of the mold duplication. Firstly, a single layer non-Si-contained UV resist was spin-coated on SiO2 substrate of duplicated mold. UV imprint was performed to transfer reverse-topology patterns of the master mold into the UV resist layer. To prevent peel-off during separation, a mono-layer promoter was applied underneath the UV resist to enhance surface adhesion. Secondly, O2 RIE was used to remove residual layer. Thirdly, the patterns were etched into SiO2 by CHF3 RIE using the cured resist as etch block material. Finally, the duplicated mold was cleaned to remove the residual UV resist using either O2 plasma, Ozone, or, wet etching. Fig 1b illustrates a similar process that uses an intermediate Cr layer as SiO2 etch block material to achieve higher duplicated pattern fidelity. Furthermore, deeper patterns and better sidewall control could be achieved by using CHF3/O2 mixture RIE. The process requires an additional step to etch Cr using chlorine based RIE. Fig 2b shows SEMs of a master mold of 40 nm line-width/200 nm period grating and a duplicated mold using the process of Fig 1a. The non-Si-contained UV resist has viscosity about 20-30 CP. Etching selectivity to SiO2 for CHF3 RIE is about 1:2~3 (SiO2 faster). Post exposure was used to enhance chemical resistance of cured UV resist. Resist-residual-free surface on the duplicated mold was observed after O2 plasma or Ozone cleaning. The resist was developed by Nanostructure Lab at Princeton University. Critical dimension (CD) measurements of the duplication will be presented. Furthermore, the process of Fig 1b, using Cr as etch block material, will be also studied.

The mold duplication process has following highlights to significantly reduce fabrication cost and improve CD control: (1) fewest processing steps; (2) very thin residual layer due to low-viscosity (20-30 CP) of the non-Si-contained UV resist; (3) using O2 plasma or Ozone to clean cured non-Si UV resist to dramatically improve yield and throughput; (4) possibly using additional Cr intermediate layer to have very high duplicated pattern fidelity. The work will provide a reliable and low-cost mold duplication solution for industrial and R&D NIL users.

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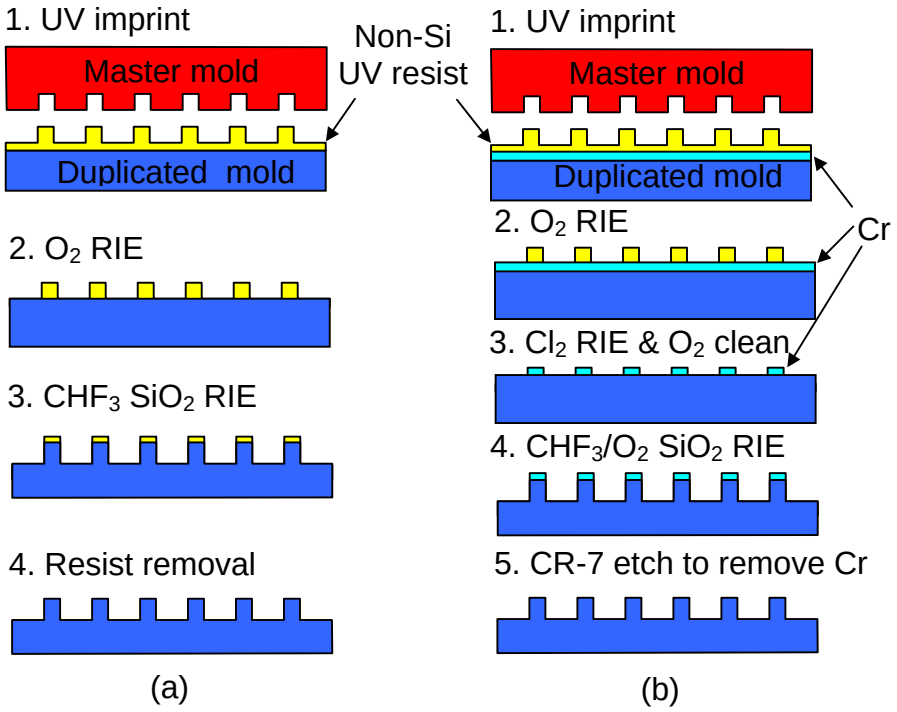

Figure 1 Schematics of imprint-direct etch process using single layer non-Si-contained UV resist for NIL mold duplication (a); and, additional Cr intermediate layer as etch block material (b).

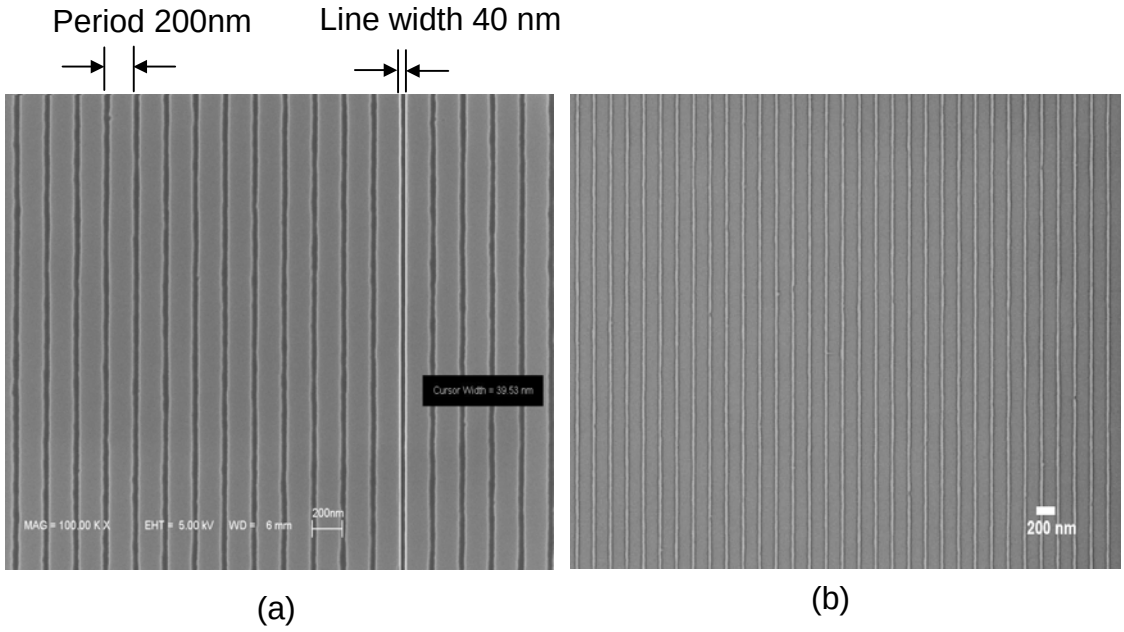

Figure 2 SEMs of a master mold (grating of line width 40 nm, period 200 nm) (a); a duplicated mold using the imprint-direct etch process (b).