# Nanoimprint Lithography for Sub-10 nm Complex Patterns

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Nanoimprint lithography (NIL)[1] is a low cost nano-patterning technology based on the mechanical deformation of a resist. Great progresses have been made in recent years. Dense lines with half pitch down to 7 nm on nanoimprint resist,[2] and metal crossbar structures with half-pitch down to 17 nm were fabricated by nanoimprint lithography.[3] However, the molds used to pattern those features were all generated based on a process that involved cleaving a super-lattice sample and etching the facet surface differentially. Therefore, those patterns all had little information content and limited applications. Here, we report our progresses on high-resolution NIL of complex patterns using molds made by electron-beam lithography (EBL). These molds can be used to generate patterns with high information contents, thus wide range of applications. For example, figure 1 shows a scanning electron microscope (SEM) image of nested Ls at 12 nm half-pitch in nanoimprinted resist. Dense lines at 12 nm half-pitch, isolated lines with line-width less than 10 nm and sharp corners were all successfully imprinted.

We used a UV-curable nanoimprint process with a double layer of spin-coated resists[4] and a custom designed nanoimprint machine.[5] The nanoimprint mold was made by EBL using hydrogen silsesquioxane (HSQ) resist and salty development.[6] We achieved successful nanoimprint results of various patterns (figure 2) using either of the two approaches: use the developed HSQ resist as mold directly[7], or transfer the HSQ patterns onto Si by RIE first and use the etched Si as mold.

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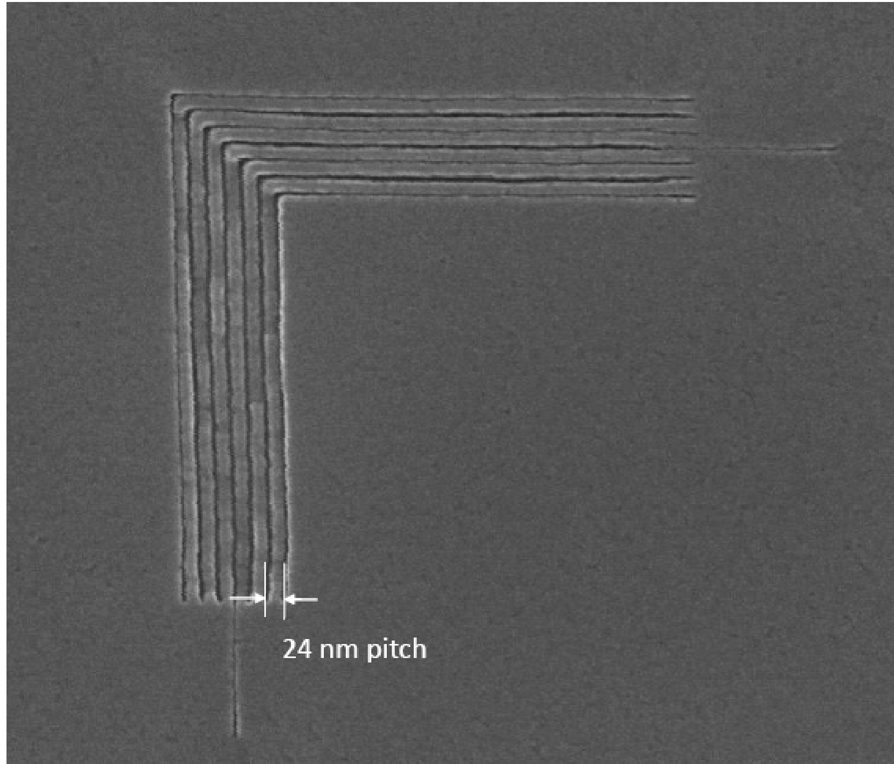


Figure 1. SEM image of nanoimprinted nested Ls on UV-curable nanoimprint resist using an EBL patterned HSQ mold. It shows dense lines at 12 nm half-pitch, sub-10 nm isolated lines and sharp turns all together.

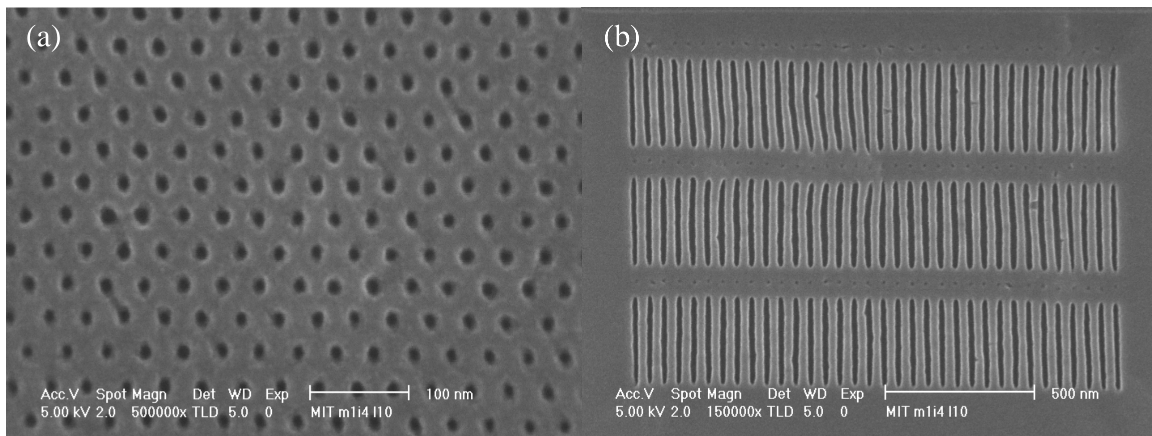


Figure 2. (a) SEM image of nanoimprinted dots array on UV-curable nanoimprint resist using a Si mold. The dots array has a pitch of 35 nm in hexagonal lattice. The diameter of the dots is about 10 nm. (b) SEM image of nanoimprinted lines and dots array.