

Fabrication of Si nano-pillar array with an areal density of $10^{12}/\text{in}^2$ and its nanoimprint lithography application

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The formation of high density nano-dot arrays is an important and challenging area for scientific interest and engineering application in diverse devices. Here, we will present the critical fabrication issues in the fabrication of high density nano-structures and report the results of 25 nm pitch Si nano-pillar array and 15 nm pitch resist nano-dot array. Especially, Si nano-pillar pattern of 25 nm pitch was transferred to the polymer surface by nanoimprint lithography (NIL).

In this work, we employed the e-beam accelerating voltage of 100 kV and 30 nm thick HSQ resist. Processing steps for the formation of Si nano-pillar array is composed by e-beam lithography, Si etching by Cl_2 plasma, and strip of remain resist. From the process, we fabricated the Si nano-pillar array of the pitch size of larger than 30 nm as shown in Fig. 1a~1c without any problem. However, resist patterns below the 25 nm pitch were not isolated and merged each other due to the e-beam proximity effect. We proposed the double development method (TMAH-dilute HF-TMAH) for solving this problem. Using this method, we can obtain fully isolated resist pattern with pitches from 25 nm down to 15 nm, and the resist pattern with 25 nm pitch was well transferred to the Si substrate (Fig. 1d). The mean diameter and height of them are 20 and 45 nm, respectively. Because of another process issue of the anisotropy characteristic of plasma etching, which determines the sidewall profile of etched pattern, resist patterns of 20 and 15 nm pitch were not transferred to Si substrate. The high aspect ratio of the fabricated Si nano-pillar is adequate for the NIL stamp. Nano-dot array patterns with pitches from 50 nm to 25 nm were well imprinted using our Si nano-pillar array as a NIL stamp (Fig. 1e-1h). More detail discussions on the proximity effect as a pattern pitch and the sidewall profile of Si nano-pillar array, will be given.

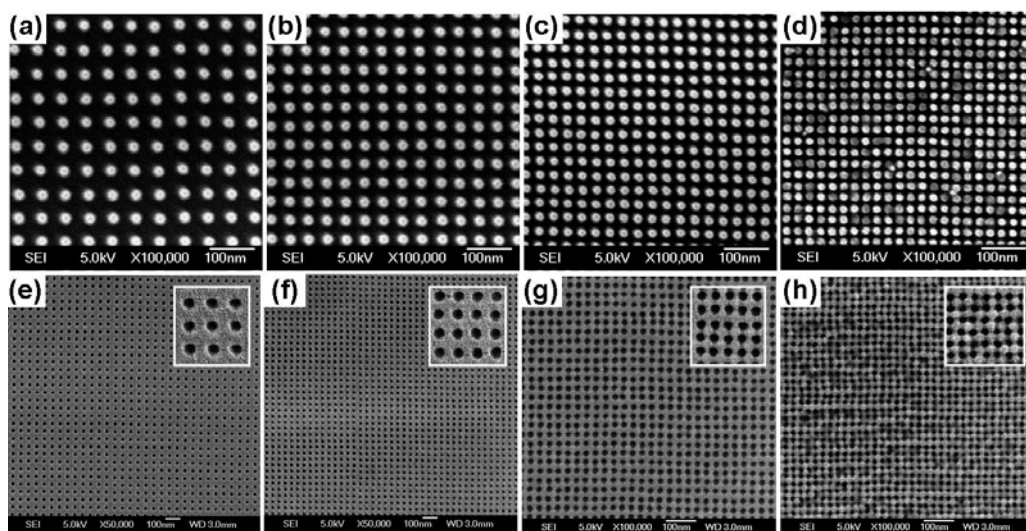


Fig. 1. Plan-view SEM images of the Si nano-pillar array and imprinted polymer patterns with pitches of (a,e) 50 nm, (b,f) 40 nm, (c,g) 30 nm and (d,h) 25 nm.