

## Electron Beam Projection Nanopatterning using Crystalline Lattice Image

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Two different paradigms exist in the development of nanofabrication process. One is top-down method to define small feature from large scale material by lithography process, the other is bottom-up method to collect atoms or molecules to build nanoscale feature. We suggested Atomic Image Projection Electron-beam Lithography (AIPEL) as one of top-down nanofabrication technologies<sup>1</sup>. AIPEL is a nanolithography process using the phase contrast generating a high-resolution image of crystal material in a transmission electron microscopy (TEM). Nano-scale patterns which angstrom-level atomic image is magnified by AIPEL process can be transferred on an electron sensitive material, such as resist and self-assembled monolayer.

AIPEL can reduce the effect of image blurring by columbic repulsion on the electron sensitive material because the magnification of atomic image makes distance between electrons away. Various patterns are obtained from tremendous atomic images of crystals in nature. Indeed, AIPEL, a kind of projection e-beam lithography technologies, has higher throughput than conventional e-beam lithography. We have developed the equipment for AIPEL with JEOL Ltd., Japan by modification of 200 kV field emission TEM. This equipment exposes atomic image magnified from 20 to 300 times on the substrate (4 mm 17 mm) with an electron sensitive material.

We fabricated 40 nm pitch size of dot and line patterns using (110) Si lattice image on hydrogen silsesquioxane (HSQ)electron beam resist. In addition, the result of AIPEL process using  $\beta$ -Si<sub>3</sub>N<sub>4</sub> with hexagonal crystal system shows different patterns except dot and line can be generated by changing atomic image.

### References

1. K. B. Kim, US patent No. 6,767,771B2