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Fundamental Design Rule for Precise Nanowires Positioning on Water Favorable Nano-pattern by Blade-coating Method

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One-dimensional nanostructures have potential as building block for nanoelectronics, nanophotonics, and nanosensors. Precise and uniform placement of nanowires on substrate surface has high significance for those practical applications. Recently, many methods were developed for positioning nanowires on specific location. Among those alignment methods, solution-based nanowire self-assembly methods have shown great potential for low-coat and large-scale nanowires alignment. Moreover, the accuracy of placement can be improved by chemical patterning on substrate. Since the solution volume/surface is of crucial importance during nanowires alignment, understanding the pattern size effects is necessary to realize high probability and accurate nanowires alignment. Although the pattern size effects on deposition probability when using solution-based methods have been noted, the fundamental knowledge for precise nanowires positioning on nanoscale pattern is still scarce.

Here, we demonstrate a pattern size dependence on nanowires deposition probability by using blade-coating method. In this work, uniform diameter Si nanowire arrays were fabricated on nano-imprint patterned Si substrate by metal-assisted chemical etching method. A series of hydrophilic-hydrophobic patterns range from nanoscale to microscale were fabricated by electron beam lithography. Since nanowires tend to be absorbed at the water/solvent interface during blade-coating alignment process, the water volume/surface controlled by hydrophilic pattern size is essential to nanowires alignment. We measured the deposition probability of Si nanowires when varying the size of patterns. High deposition probability is obtained at relatively high pattern-size/nanowire-diameter ratio patterns. Critical pattern size for different diameter nanowires was investigated. Furthermore, the influence of environmental humidity on nanowires alignment behaviors was discussed. By analysis the nanowires alignment behaviors on water favorable pattern by blade-coating method, we demonstrated the crucial role of patterning size on nanowires alignment.