Dynamic 3D Nanoparticle Assembly Technique based on Electric-field Assisted Aerosol Lithography

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Keywords: Nanoparticle assembly, Electrostatic focusing, 3D Nano-printing, IAAL
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Nanoparticles has been considered as the fundamental building blocks in nanotechnology due to their excellent properties compared to bulk materials. In spite of great advances in fabricating functional nanoparticles having designed properties, there has been few researches for assembling them into desired shapes or placing at the exact location. Therefore, developing bottom-up based nanoparticle assembly technique is essential for practical use of nanoparticles.

Ion assisted aerosol lithography (IAAL) is an aerosol-based assembly technique, which utilizes the electrostatic focusing effect to manipulate the trajectory of the charged nanoparticles. (Kim et al., 2006; Lee et al., 2010; Choi et al., 2015.) In this work, we demonstrate 3D nanoparticle assembly technique by translating the electrified mask. In previous nanoparticles were deposited through the fixed stencil mask or the PR pattern. So the shape of the nanoparticle structure was mainly determined by the geometry of the PR or mask pattern.

In this research, now the mask was being translated during nanoparticle deposition process. The shape of nanoparticle structure is now determined not by the shape of the mask opening, but the trajectory of the mask transition, which is like 3D printing technique.

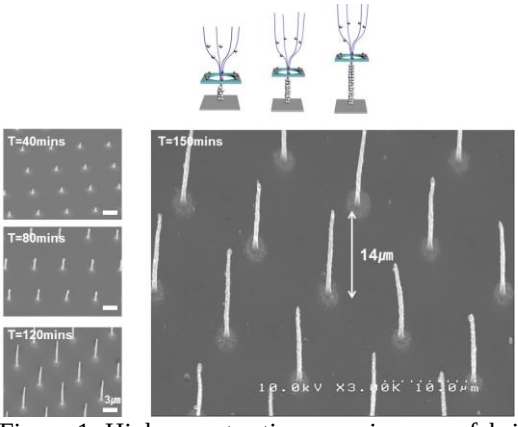

Figure 1. High aspect ratio nanowire array fabricated by translating the mask in vertical direction during nanoparticle deposition process

The high aspect ratio nanowire could be fabricated by translating the mask in vertical direction while keeping depositing nanoparticles. Moving the mask in vertical direction with the same velocity of the growth rate of nanoparticle structure, nanoparticles were keeping deposited on the structure with maintaining short total translating distance. Figure 1 shows the high aspect ratio nanowire fabricated by translating the mask in vertical direction

As the voltage applied to the substrate was also applied to the deposited nanoparticle cluster, charged nanoparticles were attracted toward to the pre-deposited nanoparticle cluster. As a result, nanoparticles tend to moving toward the nanostructure, even though the mask opening was not aligned with the nanoparticle cluster. Consequently, charged nanoparticles were continually deposited onto the top of the structure, so tilted nanowire was fabricated. If the nanoparticle cluster is too small to induce the electrostatic attraction, charged nanoparticles were deposited beside the deposited cluster, which likes nanoparticle writing. So the mask translation velocity is important parameter to determine whether the process is 3D nano-printing or 3D writing

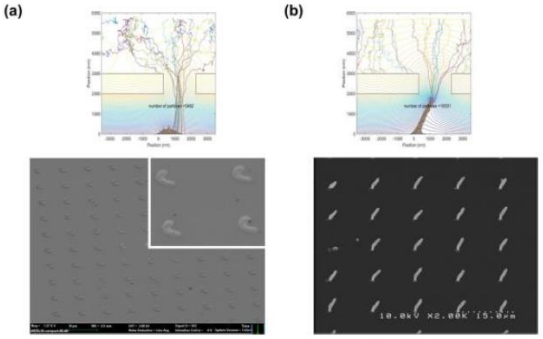

Figure 2. (a) Nanoparticle cluster fabricated with fast translation of the stencil mask; Nanoparticle writing (b) Nanoparticle structure fabricated with slow translation; 3D nano-printing.

This work was supported by the Global Frontier R&D Program on Center for Multiscale Energy System (Grant no. 2011-0031561 and 2012M3A6A7054855) by National Research Foundation (NRF) under the Ministry of Science, ICT and Future Planning, Korea.

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