Large-Area Patterning of Three-dimensional Nanoparticle Structure Arrays via Ion Assisted Aerosol Lithography (IAAL) and Multi-tip Spark Discharge

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A great deal of attention has been paid recently to the development of novel methods for fabricating nanoscale structures. In order to implement practical nanodevices using the unique features of nanostructures, large-area patterning technique is necessary. In particular, three-dimensional nanoparticle assembly method based on ion-assisted aerosol lithography (IAAL) has been reported (Kim et al. 2006, Lee et al. 2011, and Han et al. 2012) as an effective way to produce multi-dimensional assembly of nanoparticles in a parallel fashion at atmosphere.

For the case of the IAAL using a single-tip spark discharge generator, charged nanoparticles generated by spark discharge move along an electric field not by diffusion process. Thus, there exists the limitation of realizing large-area patterning along with precisely controllable uniformity. In this regard, the nanoparticles have to be injected over as wide an area as possible for the large-area patterning. We present here large-area fabrication of three-dimensional nanoparticle structure arrays using a multi-tip spark discharge generator based on the pin-to-plate type at atmospheric pressure (Figure 1).

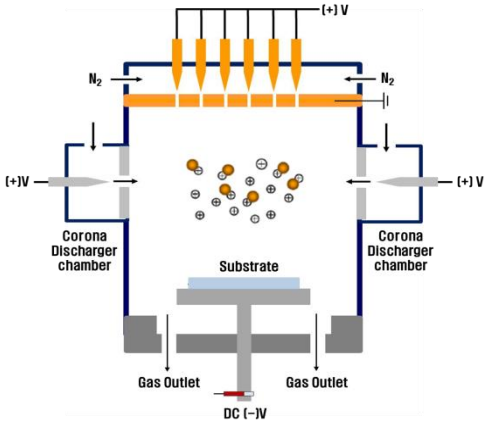

Figure1. Schematic of a multi-tip spark discharge generator

The interval and number of the tips in a multi-tip spark discharge generator are designed to minimize nanoparticle agglomeration and induce high concentration of nanoparticles. The distance between a plate and a sample is set to minimize losses of nanoparticles at the wall, as well as ensure uniformity of resulting nanostructures on a substrate.

With consideration of these conditions, large-area patterns of ordered nanostructures in the size of 50 by 50 square millimeter were fabricated on the substrate in a massive parallel way (Figure 2). In addition, the shape of the nanoparticle structures was variously controlled by changing the size of nanoparticles with the same prepattern formed on a substrate. Tuning the size of nanoparticles can be obtained by varying the parameters such as the electric circuit, the gap between pin to plate, and the flow-rate of nitrogen gas.

This large-area patterning technique using IAAL and multi-tip spark discharge generator will open the door to apply three-dimensional nanoparticle structures with a variety of shapes to diverse nanodevices including optoelectronics, sensing, and electronics.

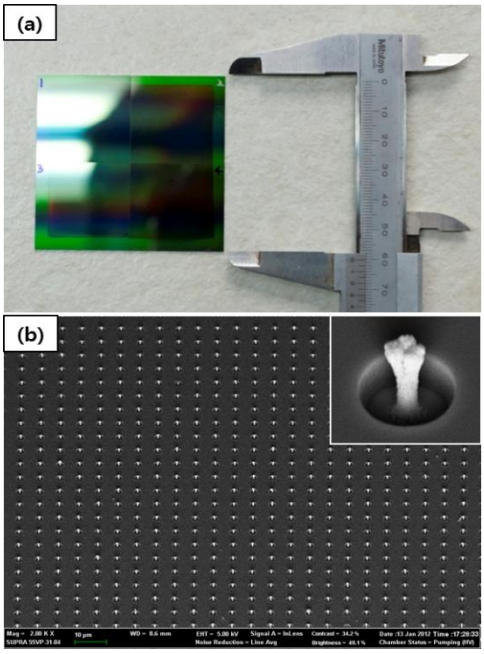

Figure2. (a) Actual image of the completed sample (b) SEM image of nanostructure array fabricated by a multi-tip spark discharge generator

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Kim *et al.*, (2006) *Nat. Nanotechnol.* **1**, 117-121.
Lee *et al.*, (2011) *Nano Lett.* **11**, 119-124.
Han *et al.*, (2012) *J. Aerosol Sci.* **52**, 80-88