Engineering Solvent-Polymer Interactions for Ultrahigh-Resolution Printing of 3D Nanostructures

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Traditionally, solvents have extensively been used as a critical component for solubilizing and processing of polymers. Several years ago, we discovered that injection of proper solvent molecules can significantly weaken the adhesion strength of polymeric interfaces due to the so-called super-lubrication effect. Using this principle, we developed a 10-nm-scale resolution printing technique, which is based on systematic combinations of nanotransfer-printing, self-assembly, and/or photolithography. This printing technique is applicable to a variety of material systems including metals, oxides, and even quantum nanostructures. In particular, this talk will introduce our recent developments of various 3D-stacked array of nanostructures and their applications for sensors and catalysts. For example, woodpile-structured Ir, consisting of highly-ordered Ir nanowire building blocks can markedly facilitate oxygen evolution reaction (OER) via combined enhancements of electrochemically active surface area (ECSA) and ECSA-specific activity compared to conventional nanoparticle-based catalysts. At the second part of this talk, I will introduce a highly effective strategy to enhance the photoluminescence (PL) of QD composite films through an assembly of QDs and poly(styrene-b-4-vinylpyridine)) (PS-bP4VP) block copolymer (BCP). A BCP matrix casted under controlled humidity provides multi-scale phase-separation features based on (1) sub-μm-scale spinodal decomposition between polymer-rich and water-rich phases and (2) sub-10-nm-scale microphase separation between polymer blocks. The BCP-QD composite containing bi-continuous random pores achieves significant enhancement of both light absorption and extraction efficiencies via effective random light scattering, collectively achieving an unprecedented 21-fold enhanced PL in a broad spectral range.

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Prof. Jung is an associate professor at the Dept. of Materials Science and Engineering of KAIST (Korea Advanced Institute of Science and Technology). His research area includes sub-10 nm nanofabrication based on directed self-assembly of block copolymers and nanotransfer-printing, printable sensor devices, nanopatterned catalysts, 2-dimensional nanostructures, and quantum-dot optoelectronic devices.

He joined KAIST as an assistant professor in 2010, and has published more than 100 journal papers and earned more than 50 patents including 7 US patents mostly in the field of nanofabrication and devices. Recently, he founded a start-up company, PICO FOUNDRY Inc. based on his group's research outcomes in the area of nanoscale patterning and optical sensor applications. He received several awards including Research Award from Ministry of Science, Future Planning and ICT, Republic of Korea and Excellent Research Award from KAIST.

He received his Ph.D. degree (2009) in materials science and engineering from MIT (Massachusetts Institute of Technology) under supervision of Prof. Caroline Ross. Prior to joining KAIST, Prof. Jung was a post-doc fellow at Lawrence Berkeley National Laboratory until 2009. He also worked for KIST (Korea Institute of Science and Technology) (2003 – 2005) and Samsung-Corning Co., Ltd. (2001 – 2003) as a research staff member.