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Templated Nano-Organization

Controlled organization of nano-sized building blocks onto nanopatterned functionalities is a promising route to the bottom-up structured nanomaterials and functional nanosystems. We explore advanced nanofabrication methodologies for nanopatterning of chemical functionalities that **template the organization of the building blocks** as small as biomolecules. In particular, we exploit cutting-edge **nanoimprint** lithography for the fabrication of templates with **sub-5 nm resolution**. We use these templates to configure the nano-sized building block into higher architectures, whose molecular-scale controlled structures are encoded in the template geometry. This unique combination of the bottom-up and top-down fabrication approaches enables us to create and control complex functional systems in the diversity of fields and application, ranging from nanoelectronics to cell biology, as described in the following research projects:

1. Integration of 1D nanostructures into circuits

During the past two decades, one-dimensional (1D) nanostructures, such as nanorods and nanowires, have been attracting a great deal of interest as building blocks for quantum electronic devices. Advances in their miniaturization combined with their unique physical properties have been extensively exploited in a variety of nanoelectronic applications. Yet, most of these are single devices, since integration of discrete 1D nanostructures into circuits has been impended by the difficulty of spatially organizing them into well-defined architectures with arbitrary geometries and long range-order. We study the **organization of discrete nanowire and nanorods onto nanofabricated templates.** We aim at introducing novel approaches for configuring 1D nanostructures into higher architectures with spatial resolution and order unattainable by state-of-the-art methods. Furthermore, we wish to apply these approaches for the **integration of 1D nanostructures into logic circuits** with the nanoscale design and order, as well as **heterogeneous integration** of different 1D nanostructures into **CMOS and multifunctional circuits.**

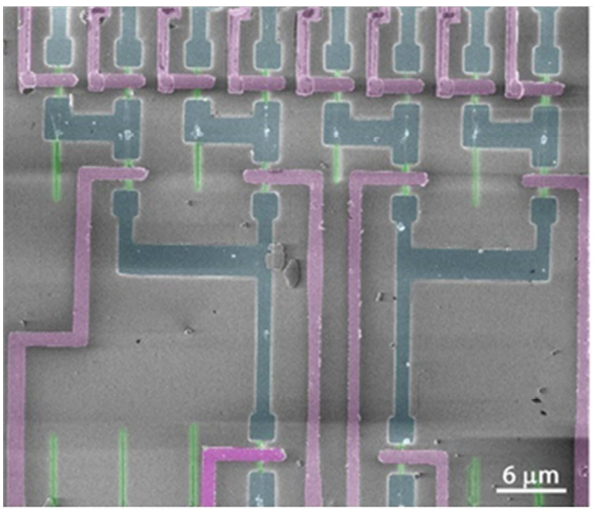

Figure 1. Nanowires integrated into a 3-bit address decoder (after ref. 1).

2. Dynamic and bi-functional biomimetic devices for the molecular-scale control and study of cell adhesion.

Controlling the spatial arrangement of extracellular adhesion ligands can regulate the signal transduction between the cell and extracellular matrix and orchestrate biochemical processes inside the cell. **Nanofabricated biomimetic devices** that controllably mimic the organization of adhesion ligands at the single-molecule provide an artificial extracellular environment, and can be used to control the spatial organization of adhesion receptors in cells. These devices can be realized via lithographically patterned arrays of sub-10 nm metallic nanodots functionalized with adhesion ligands. However, up today these devices have been limited to mimicking the organization of one single type of adhesive ligand. In addition, they have been based on rigid substrates, whereas extracellular matrix is a deformable and dynamic substance. We explore novel nanofabrication and biofunctionalization approaches to provide biomimetic cell-adhesion devices with both **dynamicity** and **heterogeneity of ligands**. These devices could open a pathway to a broad variety of complex experimental platforms that can be used for biomedical applications such as tissue engineering, as well as for fundamental studies of the structural and functional mechanisms of cell-environment interactions.

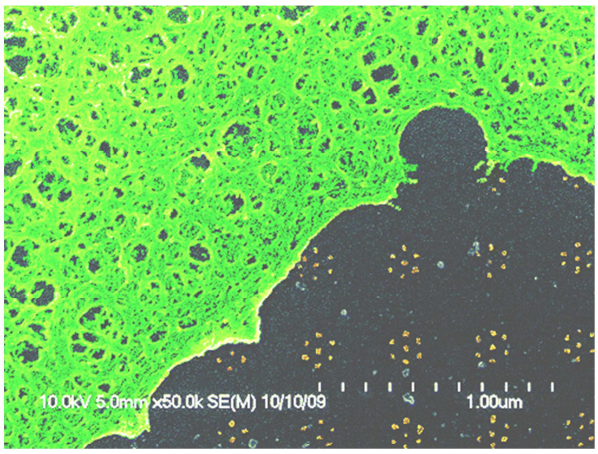

Figure 2. Fibroblast cell spread on an array of ~ 8 nm dots functionalized with adhesion ligands (after ref. 2).

(1) M. Schvartzman, D. Tsivion, D. Mahalu, O. Raslin, and E. Joselevich, "Self-Integration of Nanowires into Circuits by Guided Growth" PNAS, 100 (38), 15195 (2013)

(2) M. Schvartzman, M. Palma, J. Sable, J. Abramson, J. Hu, M. P. Sheetz, and S.J. Wind, "Nanolithographic Control of the Spatial Organization of Cellular Adhesion Receptors at the Single-Molecule Level " Nano Lett., 11 (3), 1306 (2011)