NANO HIGHLIGHT
Nanofabrication Using Viral Biotemplates for MEMS Applications

NSF Grant 0927693

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An overview of our research activities on the integration of *Tobacco mosaic virus* (TMV) templated materials and functionalized surfaces in microfabricated devices is presented. The TMV is a high aspect ratio plant virus which can be genetically modified to include cysteine residues (amino acids with thiol groups) that facilitate self-assembly of the molecules onto various surfaces [1a]. In addition, nucleation of inorganic particles (TMV*1cys*) or alternatively the attachment of peptides for explosive sensing applications (TMV-*TNT*) can be achieved on the surface-attached viruses. Recent work has been focused on combining the bottom-up self-assembly with top-down micromachining for the development of patterned functional surfaces for Li-ion batteries and selective nanosensors.

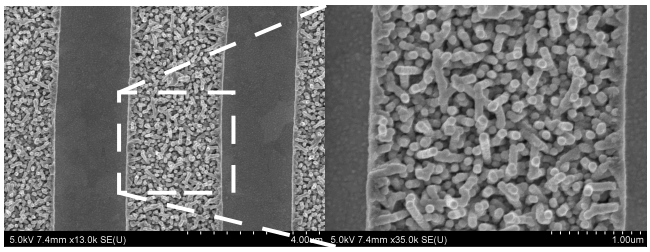

Figure 1. Nickel-coated TMV lines patterned using lift-off

The robustness of the metalized TMV has been utilized to produce patterned nanorods arrays using conventional lithography [1b]. Fig. 1 shows nickel-coated TMV fabricated using lift-off. This process can be modified to facilitate patterning of uncoated TMV, which requires narrower stability windows (pH 2-10, T≤60°C). In this case, photoresist can be removed with a developer/buffer mixture, where addition of the latter reduces the otherwise highly basic solution to a pH of ~9. This process will be used in the patterning of selective sensor surfaces. Here, preliminary experiments with TMV-functionalized quartz-crystal microbalances exposed to TNT vapor have been conducted. These results (Fig. 2) indicate a 300% and 50% shift in added mass for the TMV-*TNT* mutant compared to uncoated sensors and sensors with TMV*1cys* only, respectively [2].

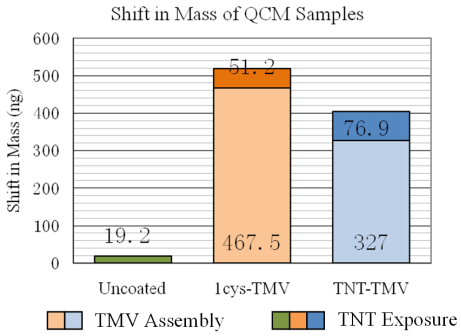

Figure 2. Mass shift for TMV sensors exposed to TNT vapor

The nickel-coated TMV is also used as a template for the synthesis of core/shell nanocomposite electrodes for Li-ion batteries. Atomic layer deposition has been used to deposit active battery materials such as TiO_2. These electrodes demonstrate high capacity and cyclic stability (~1,000 cycles, Fig. 3) due to the direct attachment on the substrate and the existence of the conducting nickel core [3].

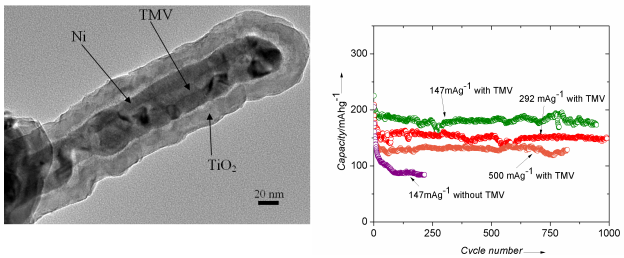

Figure 3. (a) TEM image of a TiO_2 nanocomposite deposited using ALD and (b) capacity vs. cycle number data for electrodes with and without TMV

References

[1] (a) E. Royston *et al*, *Langmuir*, 24, pp. 906-912, 2008; (b) K. Gerasopoulos *et al*, " *Nanotechnology*, 21, 2010
[2] X. Fan *et al*, *Proc. of IEEE Sensors 2010*, Waikoloa, HI, 2010
[3] K. Gerasopoulos *et al*, *Chemical Communications*, 46, pp. 7349-7351, 2010