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Nano-patterning and manipulation of genetically engineered virus nanoblocks

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Abstract

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Nano-patterning and Manipulation of Genetically Engineered Virus Nanoblocks

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Over the past several years there have been extensive research efforts on molecular electronics [1]. For the fabrication of molecular electronic devices, one type of hierarchical directed self-assembly process based on a plant virus particle (referred to as a virus nanoblock or VNB) is of great interest [2]. In this paper, we present results on the controlled 3-dimensional organization of 5nm gold nanoparticles at specific sites, using the Cowpea Mosaic Virus (CPMV) as a template, and also on the nanomanipulation of virus nanoblocks for electrical properties measurements.

The CPMV capsid is an icosahedron with a diameter of 28.4nm, formed by 60 identical copies of an asymmetrical subunit (Fig. 1a). In its natural state, the CPMV virus contains no cysteine amino acids on the exterior capsid surface. By engineering in cysteines at selected points on the virus, one can bind gold nanoparticles to produce patterns with specific sites in three dimensions. In this study, two different cysteine-containing mutants, designated BC and EF, were used to produce two different patterns on the CPMV capsid (Fig. 1b). Fig. 2 shows the direct experimental evidence of site specific attached gold nanoparticles on an isolated genetically engineered CPMV virus. As the numbered particles show, the observed pattern on the virus agrees very well with the model. It is also noted that the pattern of gold binding is distinctly different for the different CPMV mutants. This clearly demonstrates that the gold particles are clearly binding to the cysteine thiols, and not just associated with the capsids through non-specific binding, indicating a strong covalent bond between the Au particle and the S atom in the cysteine residues of the protein.

Fig. 3 shows an electrical test structure fabricated for electrical characterization of the genetically engineered CPMV virus with site-specific attached gold nanoparticles. A FIB was used to cut through the gold contact pad with a specified gap. The gap shown is about 35nm, which is smaller than the size of an isolated VNB (~40nm), illustrating that the opening is controllable to isolate a few VNB. Actual samples are also TEM ready in plane view geometry for high resolution imaging. Using a SEM with a nanomanipulation system (Zyvex S100), dispersed VNBs on the Au contact pad can then be isolated and characterized *in situ*. Fig. 4 shows an isolated gold nanoparticle cluster picked up by a probe, ready for insertion into the gap of the test structure shown in Fig. 3. Our results clearly demonstrate the feasibility of controllable nanopatterning and *in situ* manipulation of an isolated genetically engineered CPMV virus [3].

References

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[3] This research was supported by DARPA Moltronics Program. The authors thank the Scripps Research Institute for the CPMV samples.

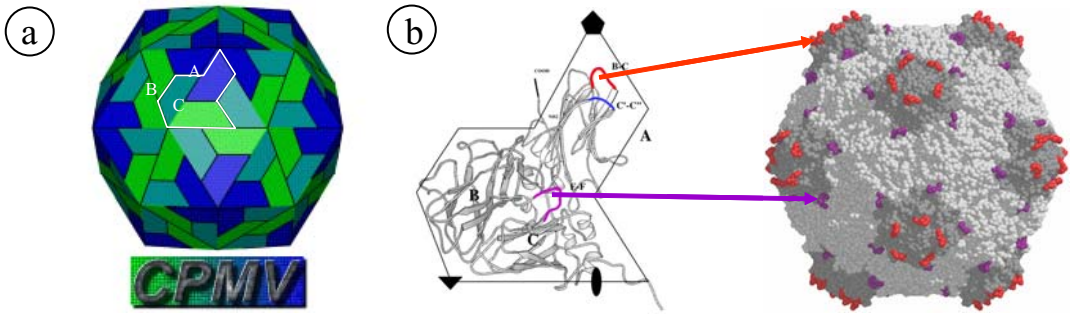

FIG. 1. (a) Schematic of icosaheral CPMV with the asymmetric subunit outlined in white. (b) Structure of the asymmetric subunit. Two different cysteine-containing mutants, designated BC and EF were used to produce two different patterns on the CPMV capsid.

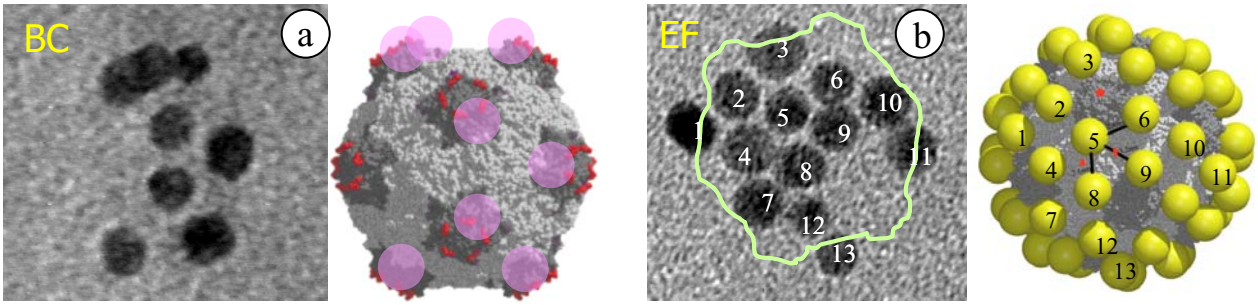

FIG. 2. (a) TEM image of gold particles bound to an isolated BC mutant CPMV virus and the corresponding model. (b) With EF mutant. The grid was not stained, so the virus is not visible.

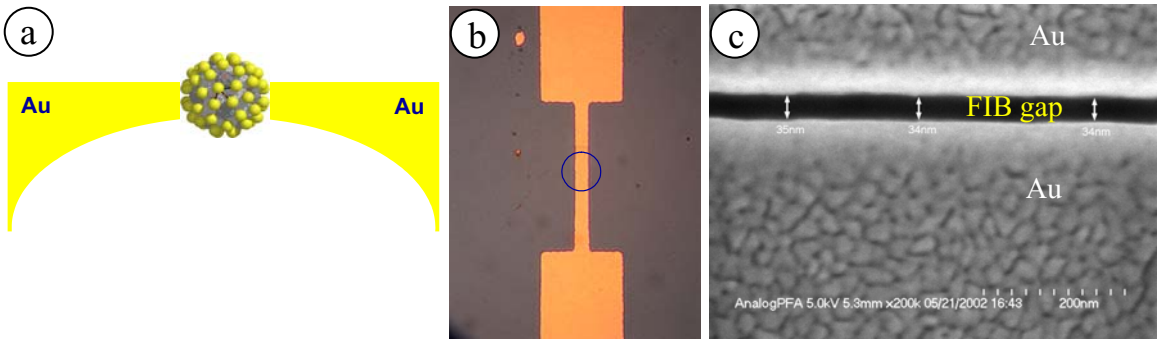

FIG. 3. (a) Electrical test structure. (b) Fabricated gold "dog-bone" looking structure on Si wafer. (c) SEM image of Focused Ion Beam (FIB) cut through the gold contact pad shown in (b).

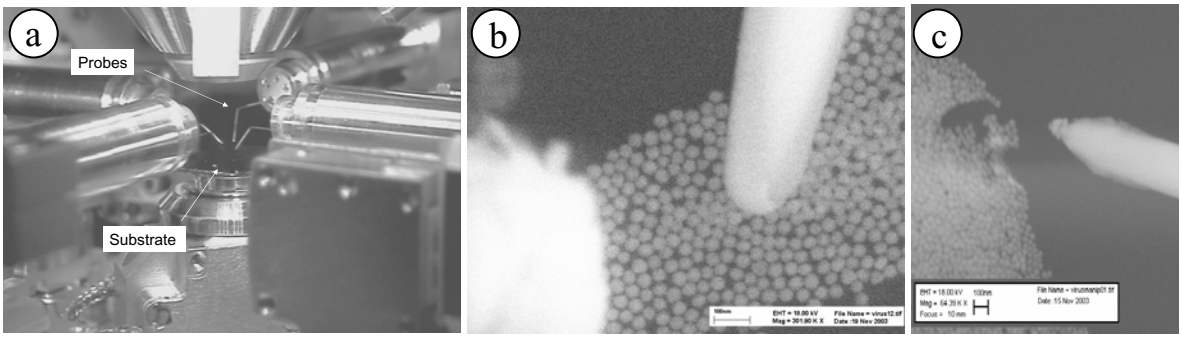

FIG. 4. (a) The Zyvex S100 Nanomanipulator in the Leo 1530VP FEG/SEM. SEM images of (b) a probe on dispersed gold nanoparticles and (c) a gold particle cluster picked up by the probe tip.