Integrated eBL Resist/Tobacco Mosaic Virus Structures for Micro- and Nanofluidics

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Abstract
Tobacco mosaic virus (TMV) is an unusually resilient RNA/protein tube with a length of 300 nm, a diameter of 18 nm, and central channel 4 nm in width. It withstands pH values from 2.5 to 8.5, temperatures up to 90ºC, and a wide range of organic solvents . TMV is structurally and chemically well defined, very well characterized, and it has become a versatile biotemplate in the field of the nanosciences [1-4].

The properties of fluids and flow processes at the nanoscale, especially below 30 nm, are largely unknown. The main experimental hurdle is the design of channels or tubes (or other conducts) that are chemically and structurally well defined down to (nearly) atomic dimensions. We integrated single TMVs in micro- and nanofluidic devices, with the aid of nanofabrication techniques. E.g., electron beam lithography (eBL) was employed to construct hydrophobic barriers to prevent undesired fluid movement on TMV's outer tube surface (Figure 1). Due to TMV's surprising chemical and thermal stability, it is compatible with positive (PMMA) and negative (mrEBL6000.1) eBL resists (Figures 2,3), both spin-coated from anisole solution. The key steps of the fabrication (prebaking of resists and development of the samples after eBL) were overcome by reducing the prebake temperature to 50 ºC, and by using only organic solvent in the development process. The successful binding of antibodies to the TMV surface shows that the virus particles are structurally and also chemically intact after the lithography process.

References
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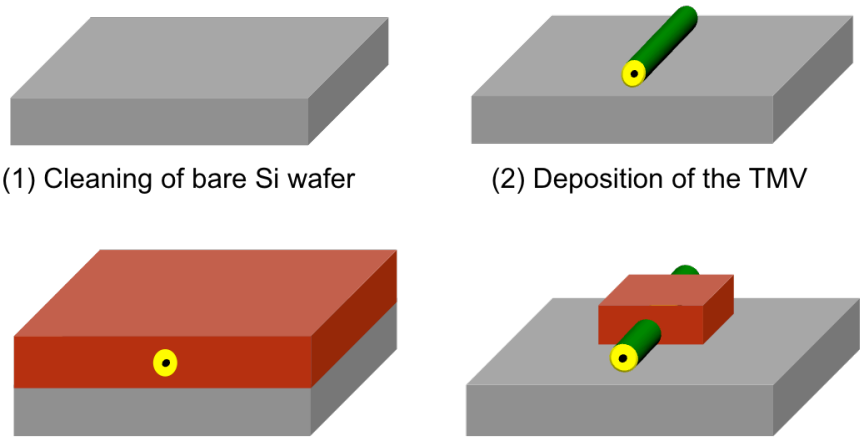
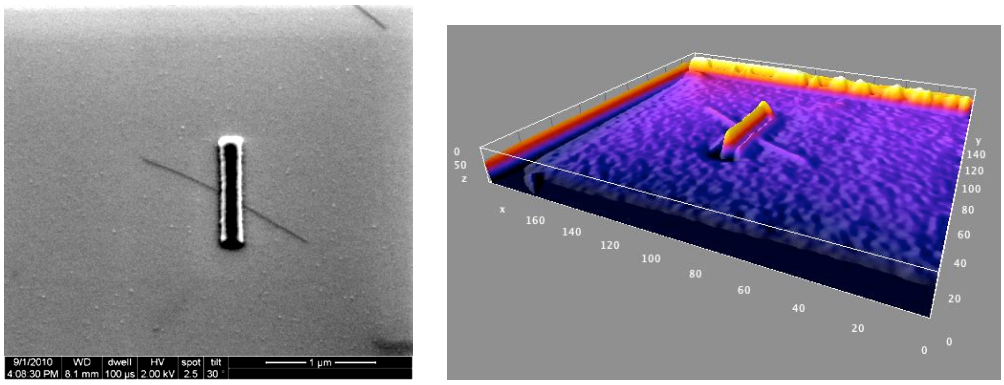
[2] Anan Kadri, Edgar Maiß, Nadja Amsharov, Alexander M. Bittner, Sinan Balci, Klaus Kern, Holger Jeske, Christina Wege, Virus Research **157** (2011) 35-46.
[3] Anna Mueller, Fabian J. Eber, Carlos Azucena, Andre Petershans, Alexander M. Bittner, Hartmut Gliemann, Holger Jeske, and Christina Wege, ACS Nano, **5** (2011) 4512-4520.
[4] Sinan Balci, Kersten Hahn, Peter Kopold, Anan Kadri, Christina Wege, Klaus Kern and Alexander M Bittner, Nanotechnology, **23** (2012) 000.

Figure 1



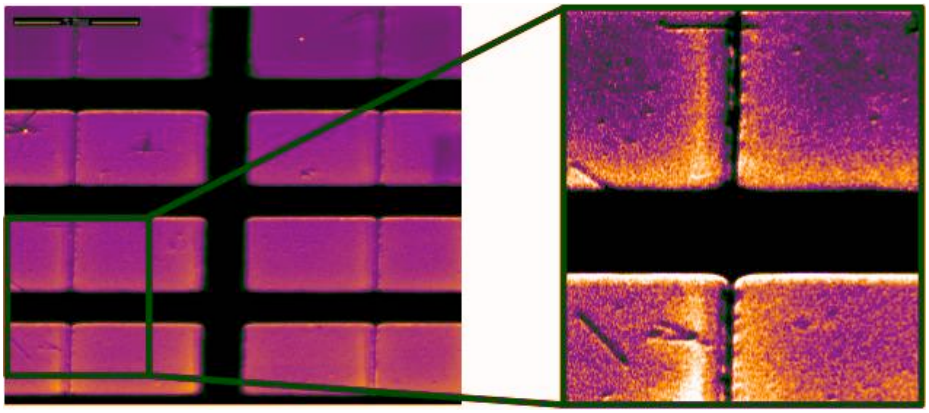
Virus nanotube immobilization through negative resist mrEBL6000.1 (fabrication)

Figure 2



TMV particle covered by a rectangular block of polymer resist (mrEBL6000.1). Image size: 3.7x3.4 µm

Figure 3



TMV particles inside a polymer resist grid (PMMA). The particle at the bottom can be separately addressed by two liquid containers (left and right). Grid size: 4.1x2 µm