Fabrication of Cellulose Nano-Structures via Focused Electron Beam Induced Conversion

T. Ganner, J. Sattelkow, H. Plank
Institute for Electron Microscopy and Nanoanalysis
Graz University of Technology, 8010 Graz, Austria
harald.plank@felmi-zfe.at

B. Rumpf, R. Winkler
Graz Centre for Electron Microscopy, 8010 Graz, Austria

M. Eibinger, B. Nidetzky
Institute of Biotechnology and Biochemical Engineering,
Graz University of Technology, 8010 Graz, Austria

D. Reishofer, S. Spirk
Institute for Chemistry and Technology of Materials,
Graz University of Technology, 8010 Graz, Austria

During the last decades direct-write fabrication on the micro- and nano-scale has attracted enormous attention in science and technology due to simpler, faster and more flexible process capabilities. Within this pool of technologies, focused electron beam induced deposition (FEBIP) gets increasingly important as it combines real nanoscale resolution with high flexibility concerning the pattern geometries which is indispensable for rapid prototyping applications. While FEBIP relies on the electron assisted, localized dissociation of gaseous precursor molecules injected via fine capillary needles, this principle can't be applied to typical cellulose precursor as the required evaporation temperatures mostly lead to chemical decomposition destroying the intended bio-functionalities. To overcome the latter but still provide FEBIPs high flexibility we here introduce an approach, which allows the fabrication of functional cellulose structures in the sub-100 nm regime. In more detail, we use the cellulose derivative tri-methyl-silyl-cellulose (TMSC) solved in organic solvents and then used for the fabrication of thin films (20 – 200 nm) via spin casting. Traditionally, these TMSC layers are then subjected to acidic vapors which transfer the TMSC in pure cellulose. In our approach we replace this large scale transformation by highly localized focused electron beam induced conversion (FEBIC, Fig. 1). This contribution will not only introduce the processing approach but also discuss its underlying mechanism and demonstrate the successful fabrication of sub-100 nm cellulose features. The maintained cellulose functionality is finally proven by classical enzyme degradation studies, which confirm the suitability of FEBIC for the fabrication of highly complex, on-demand cellulose nano-structures (Fig. 2) in science and technology[1].

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[1] Ganner T. et-al (2016). Direct-Write Fabrication of Cellulose Nano-Structures via Focused Electron Beam Induced Nanosynthesis. Sci. Rep., 6, 32451.

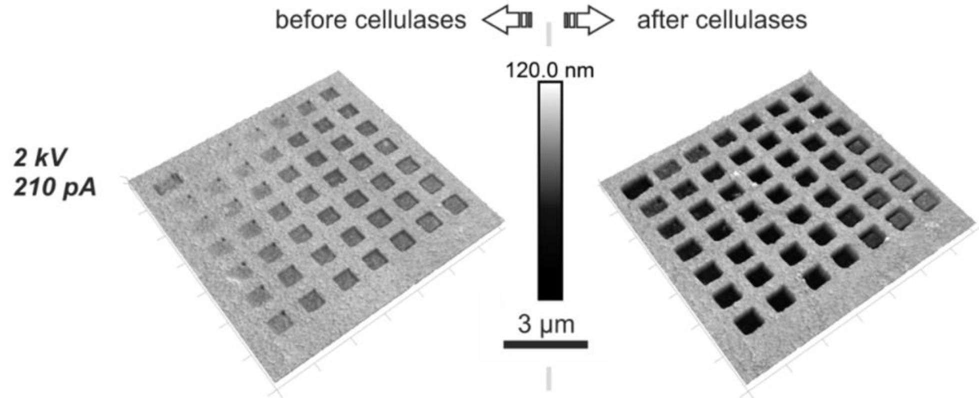

Figure 1: Atomic Force Microscopy (AFM) height image of an e-beam processed TMSC film after patterning (left) and after exposure to highly cellulose specific enzymes. Each single boxes correspond to different e- doses for comprehensive scaling insights as discussed in detail in the contribution.

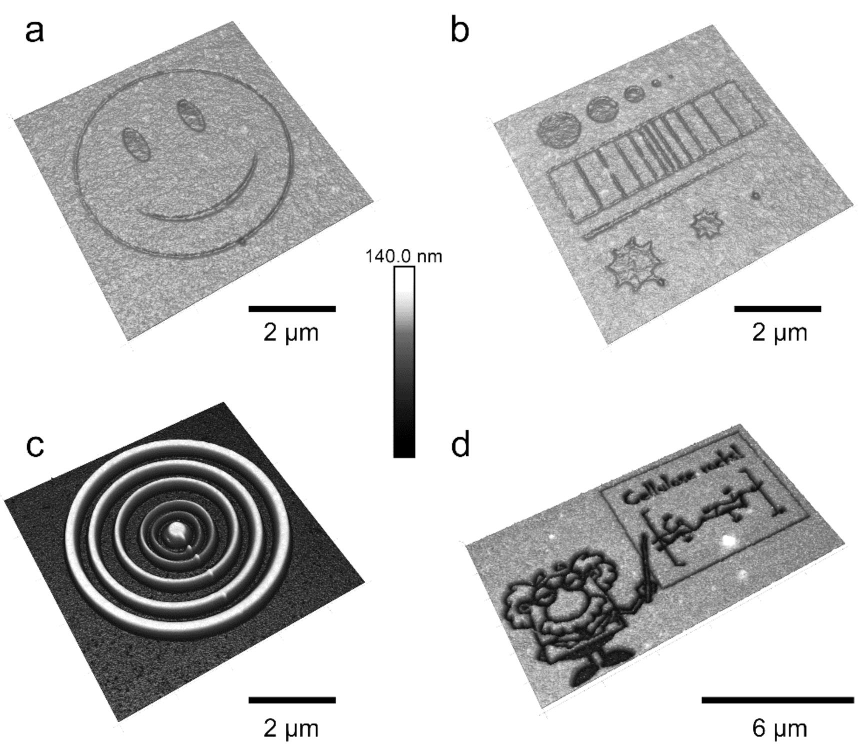

Figure 2: Representative AFM height images revealing FEBICs high flexibility (a and d) together with the possibility to fabricate cellulose nanostructures via negative (b) or positive (c) fabrication routes.