Focused Electron Beam Induced Processing: An Application Perspective

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Additive direct–write manufacturing has become an integrated part in science and technology over recent years. The tremendous advantage of such methods is the ability to deposit complex structures in a single step which eliminates templating as typically used in resist-based processes. This not only expands the applicability to even non-flat surfaces but also simplifies the processes itself. While applications on the micro- and meso-scale are meanwhile well established in industrial production such as roll-to-roll processes, inkjet printing or imprint lithography, the expansion to the lower nanoscale is still an ongoing task. Promising candidates for accomplishing such dimensional requirements are photons, ions or electrons as demonstrated by numerous proof-of-concept studies during the last decade. A very special method is focused electron beam induced processing (FEBIP) as it uses a nanometer-sized and widely non-invasive particle for local chemical processes such as modification, etching or deposition. During the last decade enormous fundamental understanding of FEBIP processes was gathered which finally led to several innovative application concepts. Therefore, this technique is at a turning point towards real applications which will be the focus of this talk.

First of all a state-of-the-art picture will be drawn by briefly overviewing several application concepts ranging from nano-lithography to magnetic applications to sensing devices and superconductors which all benefit from FEBIDs resolution, its 3D capabilities and very special material properties. Next we will overview several ongoing activities in the field of plasmonics, sensors, and on-demand photovoltaics. The former becomes increasingly interesting due to the advent of rapid purification methods in conjunction with FEBIDs 3D capabilities which has high potential for plasmon based (bio)sensing applications. The sensor activities include planar as well as free-standing resonance concepts and demonstrate how such nanostructures can be operated with simple equipment making it attractive for industrial applications. Finally, latest achievements in the field of photovoltaics are presented which use a new precursor with the aim of a FEBID based power-source. In the last part of the talk, some perspectives on applications are briefly discussed which could be possible via FEBID including self-sustaining electronic circuits.

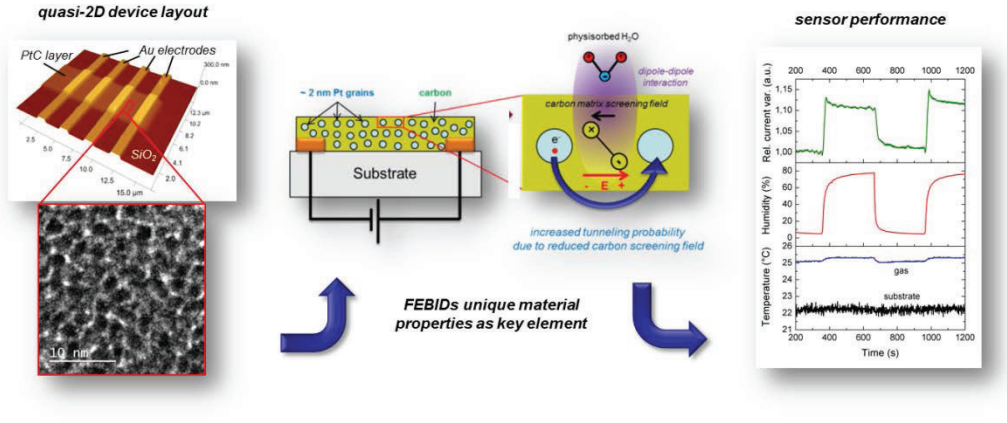

Figure 1: a gas sensor platform which bases on the nanogranular, metal - matrix structure of FEBID deposits consisting of ~ 2 nm Pt grains which are embedded in a carbon matrix (TEM image bottom left). The spatially homogeneous distribution achieved via FEBID enables the application of quantum mechanical processes (variable tunneling barriers) as sensing mechanism (center and right) in a fast, reversible and even quantitative manner.

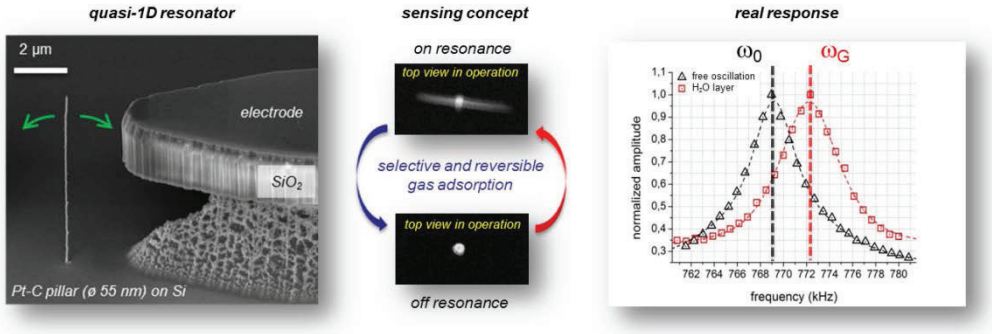

Figure 2: another gas / pressure sensor concept based on free-standing quasi-1D nanopillars (left) which change its oscillation behavior in the presence of gas adsorption caused by specific binding or local pressure variation (center). The highly sensitive reaction down to quasi-monolayers (right) is based on the very small sensor dimensions together with the special nano-mechanical properties of FEBID materials which can precisely be tuned to optimize response characteristics.