Electrodeposited metal nanotube/nanowire arrays in mesoporous silicon and their morphology dependent magnetic properties

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Porous silicon in the mesoporous regime is used as template for the electrodeposition of ferromagnetic metals within the pores to fabricate self-assembled three dimensional arrays of nanotubes (figure 1), nanowires (figure 2) or nanoparticles. Depending on the electrochemical deposition-parameters the geometry of the metal deposits can be tuned and thus desired magnetic properties can be achieved.

In the frame of this work porous silicon templates prepared by a conventional and a sophisticated anodization technique [1] are filled with diverse ferromagnetic metals to fabricate nanocomposite systems with distinct magnetic properties. Correlated to the used materials, electrolytes and electrochemical parameters there are multiple possibilities to tailor the magnetic behavior through morphology, shape, size and interfaces of the structures. One critical parameter for this purpose is the roughness of the pore walls and the surface of the metal structures, respectively. To vary the morphology of the templates magnetic field assisted etching has been employed and a decrease of the dendritic pore growth has been achieved resulting in smoother pore walls. Within the pores of these templates ferromagnetic metals are deposited and the modification of the magnetic properties compared to metal structures embedded in conventional etched (without magnetic field) porous silicon templates has been figured out. In the case of deposited metal wires the magnetic anisotropy between easy axis and hard axis magnetization could be increased significantly (the coercivity is more than doubled) and furthermore the magnetic behavior becomes comparatively hard magnetic. These properties can be ascribed to less magnetic coupling [2] between the nanostructures and modified stray fields due to less dendritic metal nanowires.

Furthermore the crystal orientation of deposited metal wires has been figured out by SEM (electron backscatter diffraction). Preliminary measurements show that they are polycrystalline which renders possible to neglect the magnetocrystalline anisotropy. Thus the magnetic anisotropy is mainly caused by the shape of the metal deposits which is also confirmed by theoretical assessments.

The magnetic behavior of three dimensional metal nanowire/nanotube/nanoparticle arrays with regard to morphological parameters as well as to the influence of the inner interfaces of the composites and the correlation with the electrochemical formation will be presented.

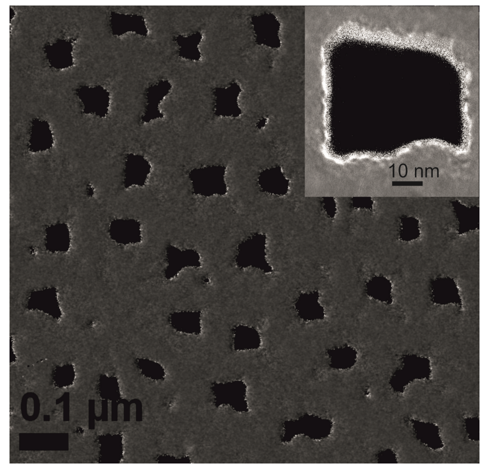

Figure 1: TEM-image of thin Ni-nanotubes covering the pores of porous silicon. The inset shows an individual pore (diameter ~ 60 nm) with a Ni-nanotube (thickness ~ 5nm) covering the wall. The template has been prepared by conventional etching.

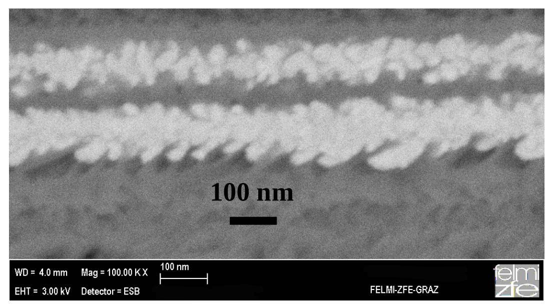

Figure 2: SEM-image (backscattered electrons) of Ni-nanowires deposited within porous silicon (prepared by conventional anodization).

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References

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