9th International Workshop on Electrodeposited Nanostructures

Direct growth of vertically integrated platinum nanowires with controlled crystallinity for sensing devices

Stegmann Christian[A], Rauber Markus[A], Hottes Martin[A], Münch Falk[A], Brötz Joachim[A], Quednau Sebastian[B], Schlaak Helmut[B], and Ensinger Wolfgang[A]

[A] Department of Material- and Geo-sciences, Technische Universität Darmstadt, Petersenstraße 23, D-64287 Darmstadt, Germany, E-mail: stegmann@ca.tu-darmdtadt.de
[B] Institute of Electromechanical Design, Technische Universität Darmstadt, Merckstraße 25, D-64283 Darmstadt, Germany

Based on their special properties including their high aspect ratio nanowires are excellent components for serving as functional elements in sensitive sensing devices.[1] Especially platinum nanowires are suitable for this application because of their high oxidation stability and sufficient heat and electrical conductivity.[2] However, to exploit the full potential of the nanowires in real-world applications it is important (i) to integrate the nanostructures efficiently into device architectures and (ii) to precisely control their intrinsic properties, e.g. by means of tuning the dimensions and the crystal structure.[3]

Our approach is based on nanowire arrays which are electrically connected to cascades and integrated in a calorimetric gas sensing device. Here, we focus on the controlled synthesis of platinum nanowires that are fabricated by pulsed electrodeposition into ion-track etched polymer membranes. The growth is performed in nanochannels with diameters ranging from 80 to 120 nm from two different electrolytes applying various pulse sequences at different temperatures. A systematic study of the influence of the electrodeposition conditions on the crystal structure is presented.

The XRD results show that the two different textures platinum <111> and platinum <100> are accessible by variation of the above mentioned variables. The platinum <100> texture is obtained by slowly increasing the overpotential at high temperatures and applied reverse pulses. The Platinum <111> texture is obtained by quickly increasing the overpotential even at ambient temperature and without applying reverse pulses. The development of the preferred crystallite orientations is explained taking into account the nucleation and growth mechanisms.

For the use of nanowires in gas sensing devices a narrow length distribution is very important. Therefore we adjusted the growth process by changing the electrodeposition parameters to compensate for the slow mass transport processes and achieve homogeneous growth. Measurements of length by HREM analysis identified electrodeposition parameters which lead to homogeneous wire growth and only small standard deviations respectively.

The presented results demonstrate that integrated platinum nanowire assemblies are sensitive to the electrodeposition conditions in terms of crystallinity and length distribution, which is important for their use in sensor systems.

References:

[1] P. Offermans, M. Crego-Calma, S. H. Brongersma, "Gas Detection with Vertical InAs Nanowire Arrays", Nano Lett. 10 (7), 2412-2415 (2010).

[2] F. Völklein, H. Reith, T.W. Cornelius, M. Rauber, R. Neumann, „The experimental investigation of thermal conductivity and the Wiedemann–Franz law for single metallic nanowires", Nanotechnology 20, 325706 (2009).

[3] D. Wang, H. P. Jakobson, R. Kou, J. Tang, R. Z. Fineman, D. Yu, Y. Lu, „Metal and Semiconductor Nanowire Network Thin Films with Hierarchical Pore Structures", Chem. Mater. 18 (18), 4231-4237, (2006).