Abstract

The role of magnetic fields on materials (trans-)formation and shaping is manifold and allows additional control over shape, crystallinity, growth direction and magnetic properties of magnetic materials that are processed or formed in magnetic fields. The effect of magnetic fields during hydrothermal synthesis of nanoparticles is reported. However, studies on magnetic field-effects during nucleation and film growth in metal organic chemical vapor deposition (MOCVD) remain elusive. The aim of this thesis is to expand the experimental space needed to understand the effects associated with magnetic field application during MOCVD process, namely directed structure growth, stabilization of magnetic phases and reduced magnetocrystalline anisotropy of magnetic materials. For example the decomposition of $Fe(CO)_5$ and $[Fe(O^tBu)_3]_2$ in magnetic fields up to 1000 mT led to increased photocatalytic performances or a reduction of magnetic anisotropy, respectively. The outcome of X-ray diffraction and photoelectron emission microscopy experiments clearly demonstrated that the characteristic phase transition from ferrimagnetic magnetite to antiferromagnetic hematite is suppressed by the applied magnetic field. In addition, X-ray magnetic circular dichroism showed that the relative ratio between ferromagnetically coupled Fe^{3+} and Fe^{2+} was enlarged, if an external magnetic field was applied throughout the process. It was furthermore found that iron oxide films obtained from zero field deposition have significantly reduced relative ratio between the Fe^{2+} and Fe^{3+} centers. These findings indicated that phase transformation from magnetite to hematite takes place through the impoverishing of octahedrally coordinated Fe^{3+} in magnetite.

It was also shown that the application of magnetic fields during CVD allowed additional control to alter the chemical composition of CVD deposits. Therefore, a set of early transition metal alkoxides ($[Ti(O^iPr)_4]$, $[V(O^tBu)_4]$, $[Cr(O^tBu)_4]$) were tested in field-assisted and zero field CVD processes. Magnetic field-assisted processes were found to boost the formation of Cr_3C_2 from $[Cr(O^tBu)_4]$ that decomposed to Cr_2O_3 under zero field conditions, while the formation of V_3O_5 and TiO_2 was observed in decomposition of $[V(O^tBu)_4]$ and $[Ti(O^iPr)_4]$, respectively. The fact that carbide is not formed in case of titanium and vanadium containing materials was explained by the high resistivity towards carboreduction of both materials. Increasing the precursor sublimation temperature of $[Cr(O^tBu)_4]$ under zero-field conditions also led to the formation of Cr_3C_2, indicating that the presence of magnetic fields during CVD causes partial pressure variations of the precursor in the reactor. This effect on pressure was also measured as increased ion currents during online mass spectrometry at varying magnetic field strength during CVD of $[V(O^tBu)_4]$ and $[Cr(O^tBu)_4]$.

In summary, the application of magnetic fields offer additional control over structure growth and transformation in field-assisted CVD. External fields provide additional

possibilities for *in-situ* control over fabrication of functional materials that need to be considered as additional parameter to influence materials formation. Further research efforts related to the fundamental processes of MOCVD are, however, necessary to unravel the full potential of magnetic fields that was demonstrated within this thesis.