Nanocrystalline ZnO from siloxy-substituted single-source precursors

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Abstract. We report here the synthesis and growth of nanocrystalline ZnO particles from solid and CVS of nanoparticles size < 10 nm from siloxy-substituted di-, tri-, tetra- and polynuclear ZnO-clusters. ZnO is of interest for a wide range of applications such as electrodes for solar cells or for electroluminescence devices. The ZnO-aggregates as molecular precursors are accessible by simple reactions of ZnR'2 with the respective silanoles R 3SiOH, affording the dimeric [(Me3Si)2NZnOSiR3]2, trinuclear [(MeZn)2Zn(OSiR3)4], tetranuclear heterocubanes [MeZnOSiR3]4 and the polymeric [(Me3SiO)2Zn]n respectively. Surprisingly, they are useful single-source precursors for low-temperature synthesis of ZnO particles in solid state and through chemical vapor synthesis (CVS).

1. Introduction

Research on nanocrystalline metal oxides has increased enormously during the past years [1]. The intense investigations are stimulated by several potential applications for this new class of materials. For example, the novel optical, electrical, and mechanical properties of devices comprising nanocrystallite semiconductors and oxides have been demonstrated in photovoltaic solar cells [2], light-emitting diodes [3] and varistors [4].

This paper reports the synthesis of ZnO with particle size < 10 nm. ZnO is an interesting material from several points of view. It is one of the few oxides that shows quantum confinement effects in an experimentally accessible size range. Furthermore, ZnO is a technologically important material. It finds widespread use in varistors and doped ZnO is a well-known transparent conductor, but is also an important substrate in heterogenous catalysis (MeOH-Synthesis) [5]. Furthermore ZnO nanoparticles offer considerable potential as material for optoelectronic devices and for other purposes such as transparent UV-protection films and chemical sensors.

Zinc oxide colloids have been prepared using many different techniques: activated reactive-, or electron-beam evaporation [6], magnetron-, reactive- or ion beam sputtering [7-10], spray pyrolysis [11,12], vapor deposition [13,14] as well as sol-gel synthesis [15,16] und microemulsions [17,18].

Conventional approaches to make nanocrystalline oxides from solutions employ hydrolysis of metal alkoxides or halides. Particles obtained from such preparation techniques have fully hydroxylated surfaces unless extreme heat treatment or chemical dehydroxylation reactions are applied, since residual hydroxyl groups influence the material properties significantly.

In this work we describe a nonhydrolytic route to prepare size-defined ZnO nanocrystals which seems promising for analogous access to other metal oxides like MgO.

2. Results and Discussion