Selective deposition of ZnO nanorods in nematic thin films by dip-coating
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In the field of thin film formation evaporation induced drying is a cost-effective and energy-saving process to selectively deposit nanoparticles from liquid phase [1]. However, heat flux and mass transport influencing the dynamic of structure formation during drying of wet films, are complex and thus, challenging to control. The aim of this study is the preparation of densely packed films composed of zinc oxide (ZnO) nano rods (Fig. 1). Due to the anisotropic shape of the ZnO particles films with low porosities can be achieved. Minimization of the interparticle distances leads to a maximum in contact area and, hence, to an increase in charge carrier mobility of the semiconducting layers. Reduction of grain boundaries which are electron barriers in crystalline materials was achieved by nanorods with high aspect ratio forming space filling films for high percolation in electronic devices [2].

ZnO nanorods, showing an aspect ratio of about 4 to 7 and a mean diameter of 20 ± 5 nm, are synthesized by a precipitation route [3] and are stabilized in ethanolic solutions [2]. Deposition of the particles onto substrates is done by dip-coating. In order to optimize the deposition process the development of an appropriate method to assess the quality of the layers is necessary. By polarizing microscopy we identify nematic structures and investigate film homogeneity. The degree of order and surface porosity is determined quantitatively by scanning electron microscopy (SEM) with subsequent image analysis on top layers and cross sections and compared to bulk characterization methods such as Raman scattering. The film thickness and roughness are analyzed by profilometry. The drying rate is varied by controlling temperature (10 °C to 40 °C) and relative humidity (10% to 60%) using a climate chamber. The film formation mechanism is controlled by subtle balances in the capillary and viscous drag regime. Moreover film drying and stress formation is investigated by tape casting methods. Parameters such as solid concentration, aspect ratio, temperature variation are varied systematically to tailor and optimize the self-organization process. After processing the optical and electrical properties of the ZnO nanorod thin films were characterized. In preliminary tests, self-organized inkjet printed structures were successfully realized with stable dispersions.

Quantitative assessment of the aforementioned process parameters allows for reproducible production of self-organized nematic structures in the order of cm² with high potential for optoelectronic applications [4]. The self-organized structures will be transferred to flexible substrates and tested in real applications. Moreover, the aim is to produce transparent oxide thin films with high order by doping so that low sheet resistances are achieved.

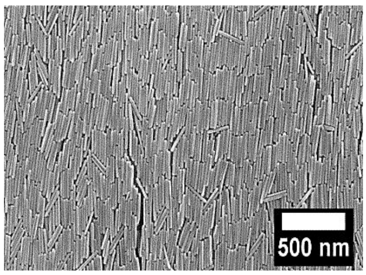

Figure 1 dense nematic thin films

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