Pulsed laser deposition of zinc oxide films

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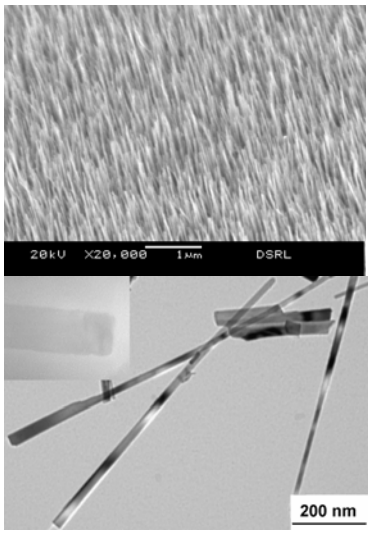
This contribution aims to provide an overview of studies of the UV pulsed laser deposition (PLD) of zinc oxide films and nanostructures. After an introductory consideration of the ablation plume, its characterization, and any modification of the target induced by the ablation process [1], the presentation will then focus on aspects of the deposited material and selected applications. The deposited films are polycrystalline, with a wurtzite structure. Deposition at elevated substrate temperatures results in oriented growth, along the (0001) direction (the *c*-axis). The *c*-axis is aligned parallel to the substrate surface normal in most such films, and film quality can be improved by hetereo-epitaxial growth on, for example, GaN or sapphire, both of which have a small lattice mismatch relative to ZnO. Other orientations have been observed on, for example, NaCl and $SrTiO_3$ substrates and explained in terms of accidental hetero-epitaxy.

ZnO films deposited by PLD, though nominally undoped, normally demonstrate *n*-type conductivity due to the presence of Zn interstitials and/or O vacancies. Stable *n*-type conducting ZnO films can be achieved by introducing a suitable dopant, *e.g.* Ga or Al, at some detriment to the crystalline quality [2].

PLD methods are also contributing to the intense current interest in the formation, properties and possible applications of ZnO nanostructures. As the accompanying figure illustrates, extended deposition can result in well-aligned arrays of ZnO nanorods (NRs), the details of which are sensitive to the precise deposition conditions [3]. These NRs are single crystal, and exhibit strong, narrow bandwidth UV and only very weak visible photoluminescence. PLD can also play a valuable role providing a nucleation layer for forming ZnO nanostructures by alternative growth methods – as illustrated by recent work demonstrating the synthesis of aligned, single crystal NRs and nanotubes (NTs) by hydrothermal methods [4,5].



Top: Tilt-view SEM image of a ZnO NR array grown by 193 nm PLD on a Si substrate at 600°C for 44 mins. The substrate had been pre-coated by a thin ZnO buffer layer (1 min PLD at 300°C). **Bottom:** TEM image of selected NRs from this sample (with high resolution TEM inset).

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