Materials Colloquium for Jan14, 2005

"Solution Chemistry Routes to Epitaxial Films"

A "What We Do" Seminar by Fred Lange,
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Physicists think of materials as condensed matter, and have successfully produced thin, epitaxial films via vapor phase routes, e.g., MBE, MOCVD, PLD, etc., over the last 40+ years. Within the last 10 years, chemical solution routes have emerged that have produced a variety of materials as epitaxial films including GaN, ZnO, $PbTiO_3$, $YBa_2Cu_3O_{7+\delta}$, and many others, on a variety of single crystal substrates. For the case of the Hi-Tc superconductor, $YBa_2Cu_3O_{7+\delta}$, a chemical solution route is preferred due to its much lower cost and equivalent properties over the conventional vapor phase route (PLD) for the production of long lengths of superconductor wires on Ni substrates.

The Lange Group has pioneered two chemical route. In the first, called Chemical Solution Deposition solutions containing metal-organic molecules, which are either spun or stamped onto a substrate, evaporate to a solid precursor and then decompose to a nano-crystalline, inorganic during heating (generally between 600°C to 1200°C). Further heating produces epitaxy via grain growth. The epitaxy of GaN on sapphire will be used as an illustration using two different precursors. In the second solution method, powders of oxides, nitrides, sulfides, etc, can be directly synthesized in a liquid. Epitaxy can be achieved by placing a single crystal substrate in such a solution. Nucleation and growth on a single crystal substrate produces an epitaxial thin film. The example used here will be the epitaxy of ZnO on (111) $MgAl_2O_4$ (spinel) in water at 90ºC. Recently, David Andeen has demonstrate that films with less defects can be produced at 90°C by a method called Lateral Epitaxy Overgrowth (LEO), where photoresist is used to mask a fraction of the substrate.

Lange's major interest has been to uncover epitaxy mechanisms, relations between processing and defects, and the possible limitations of chemical routes.