Characterization of Co-SnO₂ Films Grown By Chemical Vapor Deposition on SiO₂ and R-plane Sapphire Substrates

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This project was funded by MRSEC & shared equipment from NSF-ECS 0084703.

Motivation for SnO₂ films
- Co- or Fe-doped SnO₂ is a potential spintronic material.
- SnO₂ is a transparent semiconductor. DMS could lead to a transparent ferromagnet with optoelectronic applications.
- Co-doped SnO₂ is a promising DMS with a reported ~ 650 K Curie temperature and a giant Co moment of 7.5 +/- 0.5 \( \mu_B \) at Sn₀.₉₅Co₀.₀₅O₂ (Ogale et al., PRL, 2003). Films were grown by pulsed laser ablation.
- ALD (atomic layer deposition) with SnI₄ and O₂ is a superior method for obtaining epitaxial SnO₂ on R-plane sapphire, lattice mismatch = -0.42 (Harsta et al., J. Cryst. Growth, 2004)

Experimental Setup
ALD reactor and Loadlock (left); Schematic (right)

Experimental Results: AGM
- Magnetic moment per Co atom decreases with higher Co concentration.
- Larger error for low Co% due to XPS sensitivity limit

XPS Analysis
- Binding energy of Sn 3d₅/₂ and O 1s electrons assigned to 486.89 and 530.78 eV respectively corresponding to SnO₂.

Raman Spectroscopy
- Separate Co₃O₄ phase appears at 5% Co
- No significant SnO₂ peak shift

Conclusions
- Co-SnO₂ films were grown by CVD at 500 °C using SnI₄ and O₂ on SiO₂ substrates and on R-plane sapphire substrates.
- XRD indicates films are epitaxial on single R-plane sapphire and polycrystalline on SiO₂.
- Magnetic moments decrease with increasing cobalt concentration between 1 and 5 at%.

Future Work
- ALD for improved microstructure and control of dopant concentration. Evaluate by HRTEM
- BES for accurate concentrations/depth profile
- Hall measurement

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