Novel Real Time Optics for Thin Film Materials Research - I

Robert W. Collins, The Pennsylvania State University, DMR-0137240

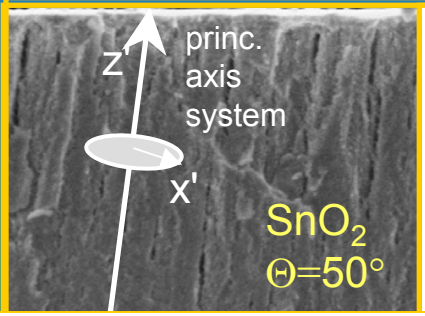
Introduction

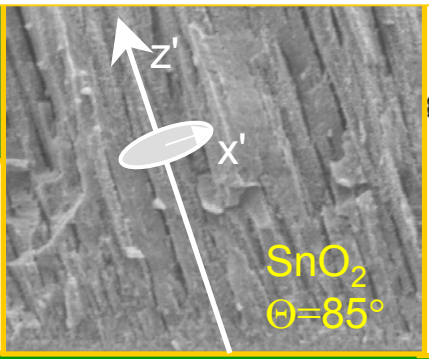
- Advanced real time optical probes of thin film deposition established in this project are being used to design novel materials for opto-electronic devices.

Selected Scientific Highlights

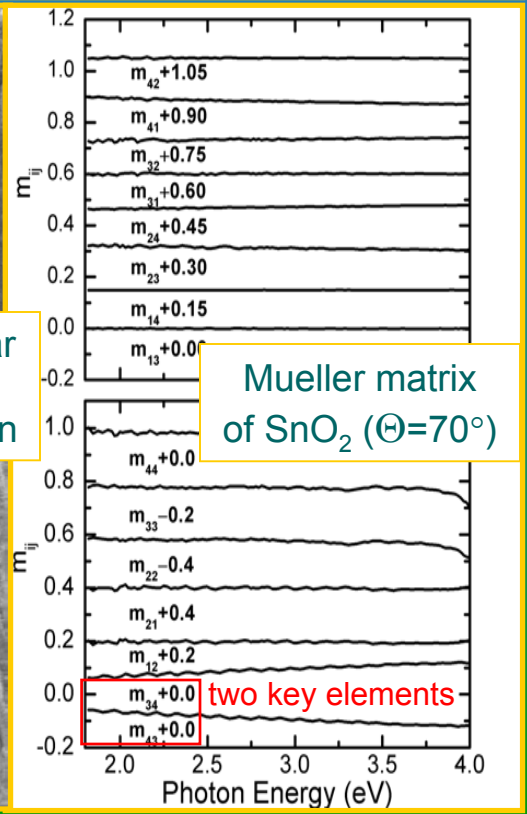
- Nanostructured thin films have been developed that serve dual roles as transparent conductors and user-designed optical filters.
- One application of these novel materials is in high efficiency thin film solar cells.

  A high conductivity allows electrical contact, while the optical filtering ensures optimum light collection by the active solar cell layer.
- A dual rotating-compensator multichannel ellipsometer developed earlier has been applied to characterize the capabilities of the films as optical filters, by measuring the indices of refraction for light waves traveling along different axes in the film.





SEM images of columnar SnO_2 films prepared by glancing angle deposition



Mueller matrix of SnO_2 (Θ=70°)

Figures (top): optical instrument for ellipsometry
(bottom left): images of columnar tin-oxide films prepared with glancing angle flux (Θ = 50° and 85°)
(bottom right): data for a tin-oxide film with Θ =70°.

Novel Real Time Optics for Thin Film Materials Research - II

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Educational Impact

Over the last year:

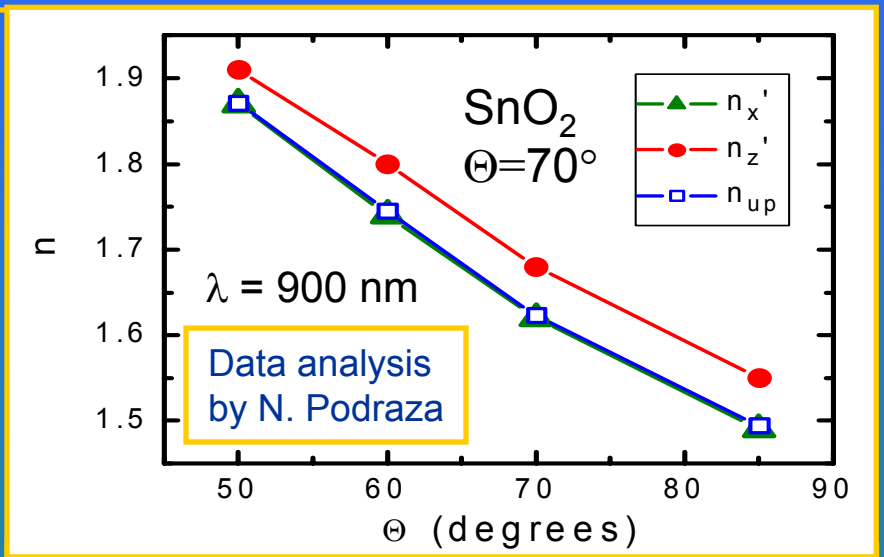
- An undergraduate student (J. Michel Flores),
- 5 graduate students (Chi Chen, Gelio Ferreira, Nikolas Podraza, Deepak Sainju, Obi Ezekoye),
- 2 Visiting scholars (Profs. K. Lim - KAIST; I. An - Hanyang Univ., Korea)

all have participated in the development and application of advanced optical instrumentation for the fabrication of novel thin film structures.

Multidisciplinarity, Collaboration, Outreach

This research involves collaborations among faculty in the Depts. of Physics, Electrical Engineering (C. R. Wronski), and Engineering Science (R. Messier, M. Horn). Students have participated in a wide variety of activities from optical instrument development to condensed matter physics to device fabrication.

Collaborations with photovoltaics industries (Uni-Solar) have led to improved processes derived from basic concepts. The university and local communities have been educated about the importance of clean power generated by lower cost thin film silicon solar cells.



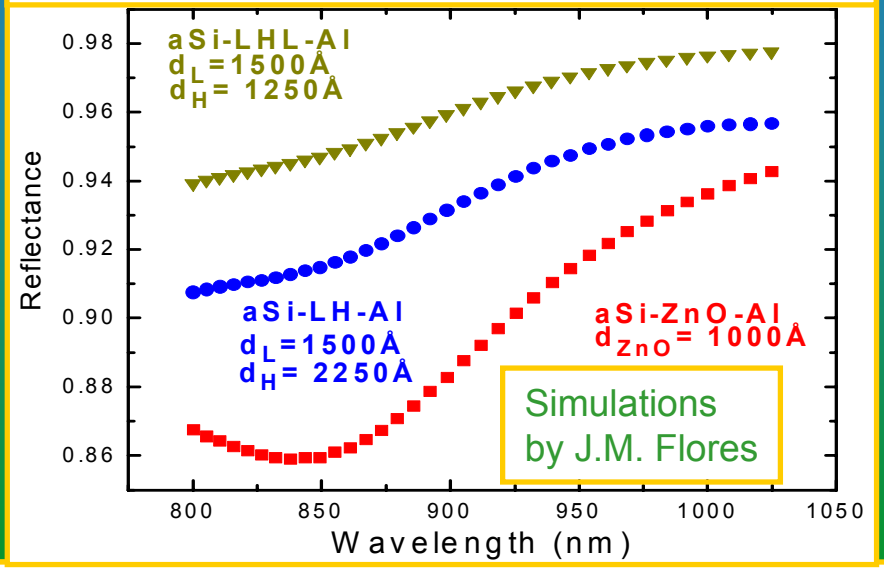


Figure: (Top) Principal refractive indices $n_{x'}$ and $n_{z'}$, and unpolarized index n_{up}, all at 900 nm, for a $\Theta = 70°$ film. (Bottom) Predicted reflectance gain by implementing optical filters (from ZnO in this case) on an Al substrate.