Wide Band Gap/Optoelectronic Materials

The Optoelectronics Industry Development Association roadmaps cite the need for standard reference materials (SRMs) and measurement methods to calibrate deposition processes and evaluate material properties. This project addresses those needs in the following areas: photoluminescence measurements of $Al_xGa_{1-x}As$ films for SRMs; photoreflectance measurements of band gap in InGaAsN; cathodoluminescence measurements to assess film quality in AlGaN; and Raman and photoluminescence measurements to evaluate stress and composition in $Al_xGa_{1-x}As$.

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The NIST program to produce $Al_xGa_{1-x}As$ standard reference materials (SRMs) for the optoelectronics industry is nearing completion. Photoluminescence (PL) determined compositions of $Al_xGa_{1-x}As$/Ge films and AlGaAs lift-off films have been compared with results of inductively-coupled-plasma optical-emission spectroscopy (ICP–OES) measurements made in the Analytical Chemistry Division at NIST. Although Ge substrates eliminated biasing the ICP–OES results with Ga or As from GaAs substrates, there was concern that the Ge substrates would alter the $Al_xGa_{1-x}As$ band gaps. However, PL measurements confirmed that band gap energies for AlGaAs/Ge agreed with AlGaAs/GaAs. $Al_{.20}Ga_{.80}As$ SRMs are to be released in September 2003.

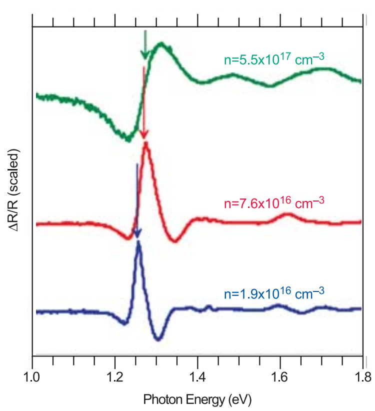

Figure 1: *PR of InGaAs films.*

Photoreflectance (PR) is a useful probe of the electronic structure of InGaAsN films, a new class of infrared optoelectronic materials. Figure 1 shows PR spectra of films with 8 % In, 0.4 % N, and varying silicon dopant and free carrier ("n") concentrations. The lines broaden and critical point energies shift upward with increasing "n". Arrows indicate the fitted band gap (lowest direct transition) energies. Higher-lying transitions (not labeled) are ascribed to splitting of both the valence and conduction bands in these alloys.

As part of a study of compositional, structural, and optical properties of AlGaN films, grown by either metalorganic chemical vapor deposition (MOCVD) or hydride vapor phase epitaxy (HVPE) on (0001) sapphire, the near-band-edge optical properties of the samples were probed by cathodoluminescence (CL) spectroscopy. Figure 2 compares low-temperature CL of films produced by different deposition processes. The near-band-edge CL lineshape is sensitive to compositional fluctuations and defect levels. The results suggest that recent HVPE grown films have improved homogeneity and crystalline quality.

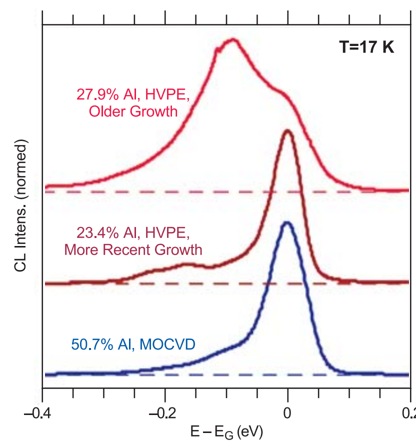

Figure 2: *CL of AlGaN films*

A paper, "Refractive Index Study of $Al_xGa_{1-x}N$ Films Grown on Sapphire Substrates," has been accepted by the *Journal of Applied Physics*.

Raman and PL spectra of $Al_xGa_{1-x}As$ have been calibrated in terms of stress and composition. Details are given in the Technical Highlights section of this report.

Contributors and Collaborators

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