Investigation of III-Nitride Materials for Space-based Solar Cells

by Abdelhak Bensaoula and Chris Boney

ABSTRACT—This project is investigating the suitability of the material *InGaN* as a candidate for photovoltaic space power generation. The effect of growth parameters on the properties of the films is under study.

THE *InGaN* MATERIAL SYSTEM HAS THE CAPABILITY OF covering almost all of the usable solar spectral range (0.5 – 3.0 eV) employed by solar cells. Based on the film composition, *InGaN* can cover from 0.70 eV up to 3.4 eV, which would be ideal for high efficiency solar cell applications. Also, it has recently been determined that the Nitride materials can offer exceptional radiation tolerance well beyond what can be achieved with conventional solar cell materials currently flown into space.[1] However, *InGaN* is currently a much less mature technology than other III-V semiconductors used in conventional solar cells.

Goal

The goal of this ongoing project is to determine the feasibility of the *InGaN* material system for use in high efficiency single and multijunction solar cells. Previously, simulations of single junction *InGaN* solar cells were undertaken to predict the effect of structural defects on the performance of the devices. Simulations verified that *InGaN* is theoretically a viable candidate for solar cell applications but that improvement in electrical and structural quality was necessary.

Results

Growth of $In_xGa_{1-x}N$ films by MBE under different growth conditions — such as *In*/*Ga* ratio, total III/N ratio, and film growth rate — have been performed. To date, we have realized a maximum indium mole fraction of approximately 51 percent based on room temperature and low temperature photoluminescence measurements. Thick *InGaN* for this project faced several challenges: large difference in volatility (evaporation) for indium compared to gallium, much lower growth temperatures needed for indium incorporation compared to pure *GaN*, and segregation of the indium during the growth which can cause compositional fluctuations.

Currently, samples in the higher indium mole fraction range exhibit some compositional fluctuations and increased background conductivity, but it is expected that further growth refinements should be able to reduce or eliminate these effects. These refinements include improved deposition parameters and exploration of a flux modulation approach to the *InGaN* deposition. Modulating the arrival of the metal and nitrogen fluxes to the substrate can improve adatom mobility at the lower growth temperatures and help suppress compositional fluctuations.

References

[1] J. W. Ager III, J. Wu, K. M. Yu, R. E. Jones, S. X. Li, W. Walukiewicz, E. E. Haller, H. Lu, and W. J. Schaff, “Group III-Nitride Alloys as Photovoltaic Materials,” *Proc*. SPIE 5530 (2004): 308-15.

CERAMIC BONDING—Dr. Nasi Medelci, research scientist in electrical engineering, with the Center for Advanced Materials (CAM), modifies a ceramic chip with laser technology effective in the improvement of bonding between diverse materials. **See report, p. 8.**