Growth and Characterization of Gallium Oxide

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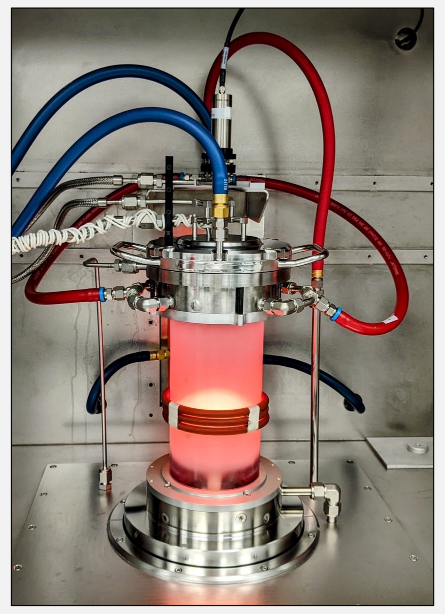
Introduction

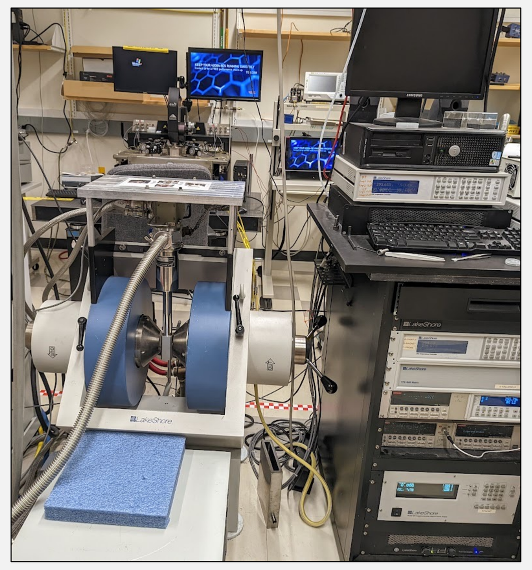
Interest in gallium oxide has skyrocketed in recent years, due to its use as a high breakdown field ultra-wide band gap semiconductor. β-Ga_2O_3 possesses high thermodynamic stability, and the material has several useful optical properties. Characterization and optimization of growth is necessary for the production of device-quality material.

Systems and Methods



Metal organic chemical vapor deposition (MOCVD) is a highly scalable method for growth of gallium oxide thin films. By manipulating gas flow, temperature, and pressure, the qualities of the crystal can be changed.

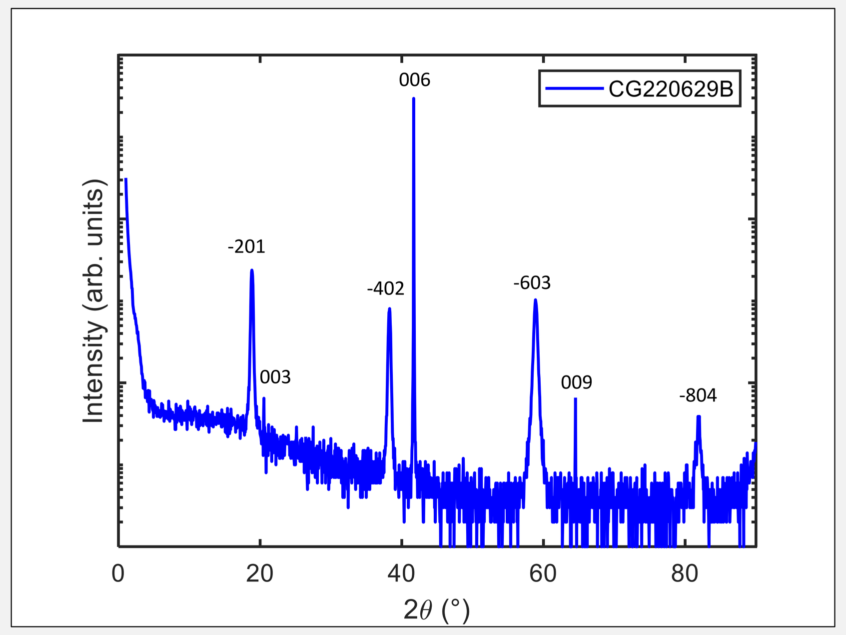
X-ray diffraction (XRD) was a main characterization technique, especially the *2θ-ω* and *ω* scans. This allowed for determination of phase purity and crystal quality of the thin films.

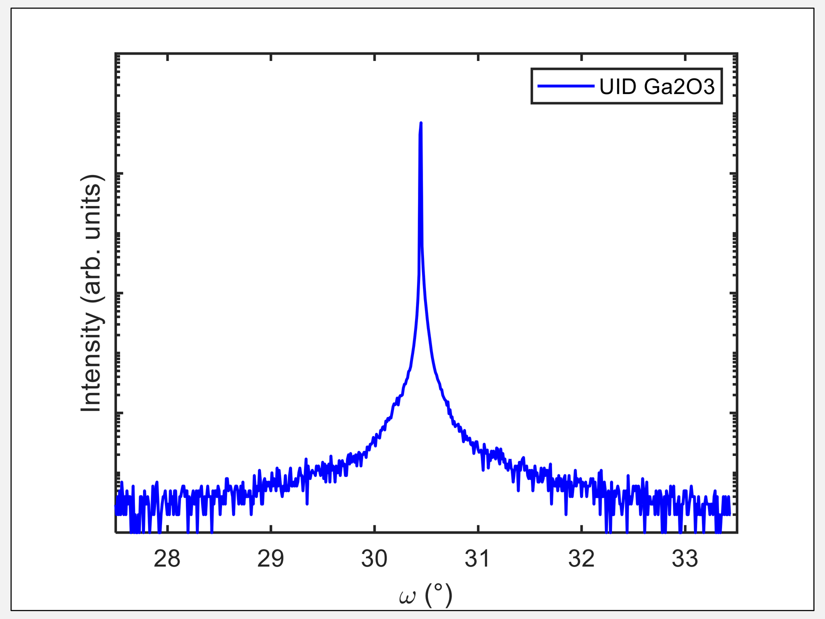


Temperature-dependent Hall measurements (mobility and carrier concentration) allow for analysis of semiconductor properties and stability.

Results

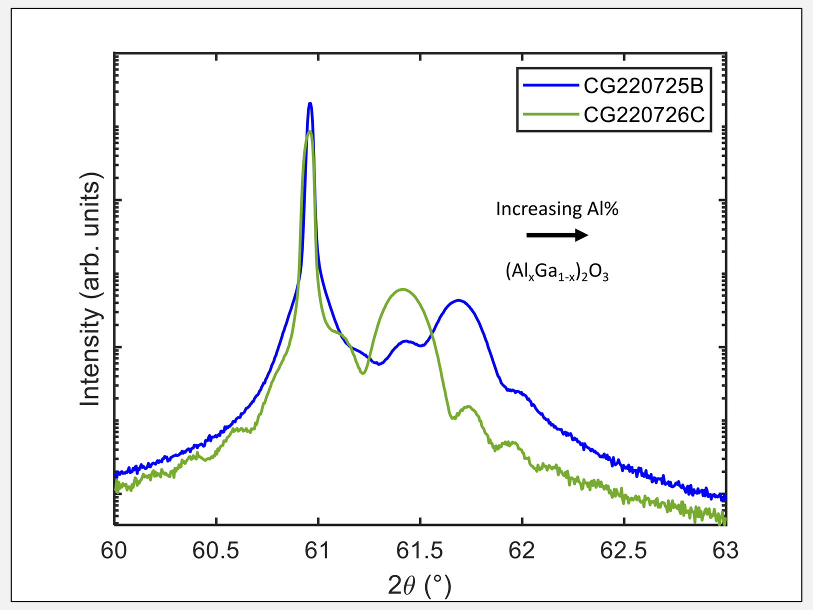
XRD characterization through the *2θ-ω* scans allows for detection of film and substrate peaks. We were able to confirm that the MOCVD technique can reliably grow phase-pure thin films. A *2θ-ω* scan of gallium oxide grown on c-plane sapphire is shown.

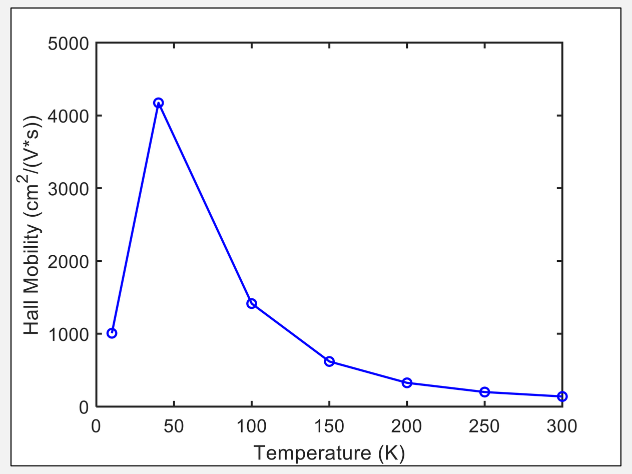


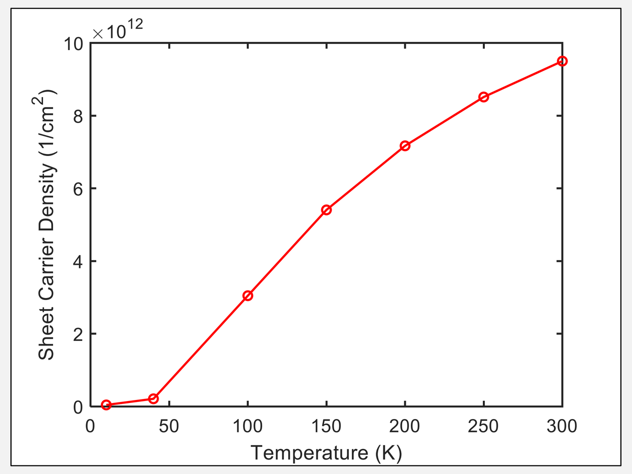


Use of *ω* scans, or rocking curves, allows for crystalline quality analysis through the corresponding FWHM value. Through growing homoepitaxial gallium oxide, we were able to produce extremely high quality films, a scan of which is shown.

Successful aluminum alloying was demonstrated, represented by *2θ-ω* scans of those films, where the substrate and film peaks are visible, and crystalline quality fringes can be seen. The graph shows two aluminum gallium oxide samples with Al concentrations of 10 and 17%.

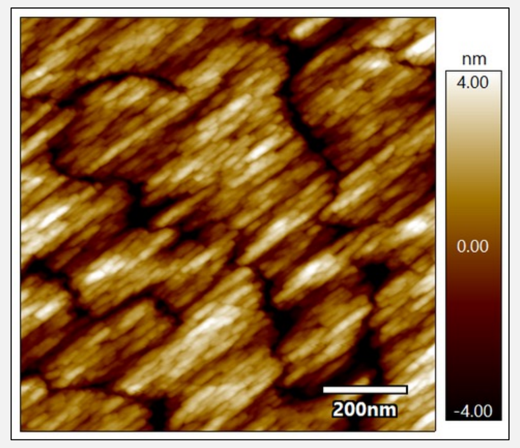


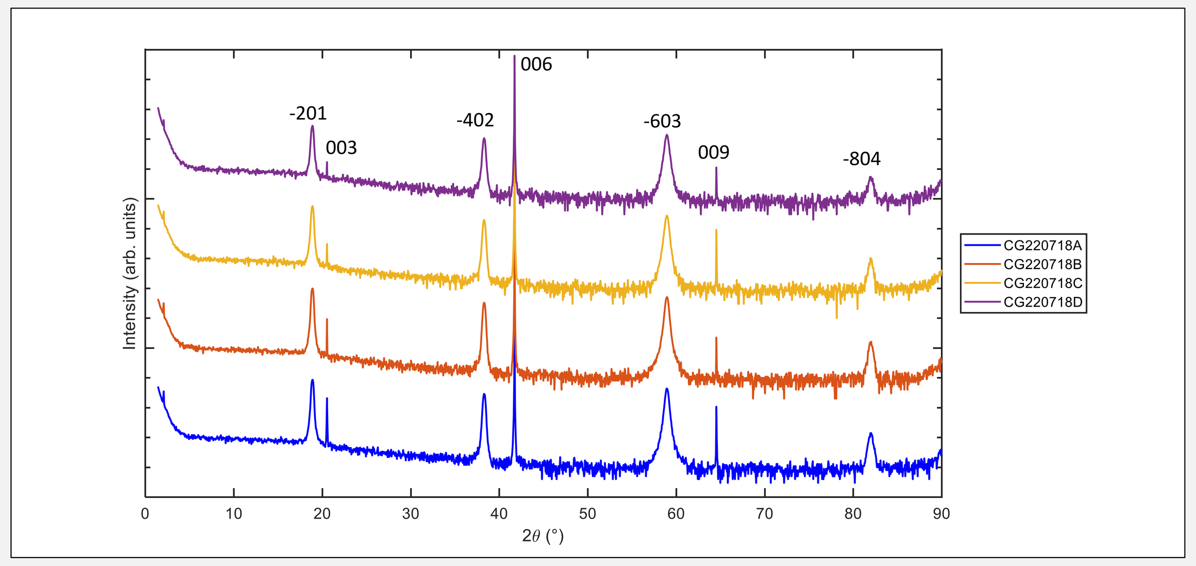




Temperature-dependent Hall measurements of mobility and carrier concentration showed excellent results. Mobility showed a peak of 4000 $cm^2/V \cdot s$ at 40 ° K. Room temperature mobility was ~140 $cm^2/V \cdot s$. Carrier concentration increased with temperature. Both properties behaved as expected in a semiconductor. Measurements were performed on a lightly Si-doped homoepitaxial gallium oxide film.

High quality and consistency were achieved through the MOCVD method, evidenced by the XRD scan comparisons and atomic force microscopy imaging (AFM) shown.





Conclusions

MOCVD-grown gallium oxide films exhibited phase-purity and high mobilities. Successful alloying and doping of the films was also showcased. Films show promise for future device applications.

In the future, further optimization of the growth process in order to reduce the surface roughness of the films will be conducted.

Acknowledgements

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