ALD Oxides for Higher Performance Power Transistors

Scientific Achievement

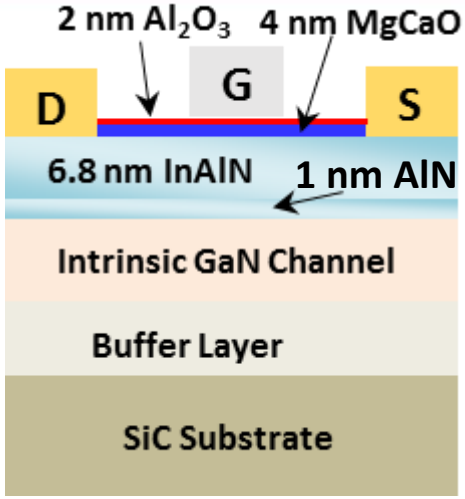
Successfully grew single-crystalline (Mg,Ca)O films epitaxially on InAlN transistors with unprecedentedly low density of defects and electron traps at the oxide/semiconductor interface.

Significance and Impact

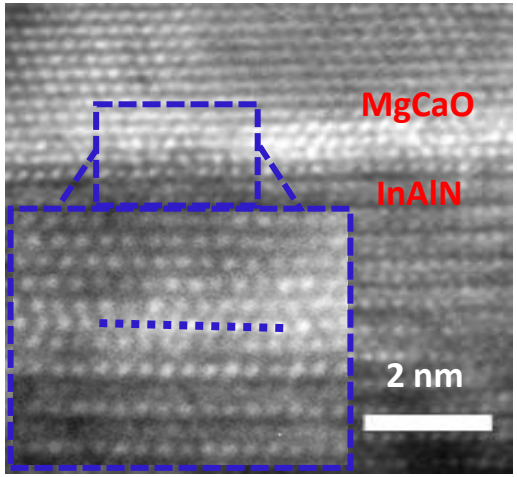
The performance of transistors using these epitaxial (Mg,Ca)O insulators was dramatically improved relative to the many non-epitaxial insulators (SiO_2, Al_2O_3, Si_3N_4, HfO_2, La_2O_3, $LaLuO_3$, and AlN) tested previously in similar devices. These new transistors will improve the efficiency of electric power transmission and use.

Research Details

- New volatile, thermally stable, and highly reactive magnesium and calcium amidinate precursors were synthesized and demonstrated to make metastable epitaxial (Mg,Ca)O layers by atomic layer deposition (ALD).
- The leakage current in the off-state was reduced by between 2 and 5 orders of magnitude relative to non-epitaxial devices.
- The noise generated by the transistors was reduced by more than an order of magnitude relative to non-epitaxial devices.
- The sharpness of the turn-on voltage was found to be near the ideal limit.



Schematic cross-section of a high-power nitride-based transistor.



Transmission electron micrograph of epitaxial $Mg_{0.25}Ca_{0.75}O$ on indium aluminum nitride.

H. Zhou, X. Lou, N.J. Conrad, M. Si, H. Wu, S. Alghamdi, S. Guo, R.G. Gordon, P.D. Ye, *IEEE Electron Device Letters* **37**, 556 (2016). DOI: 10.1109/LED.2016.2537198

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