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Sandia National Laboratories

Engineered Gate Oxides for Wide Bandgap Semiconductor MOSFETs

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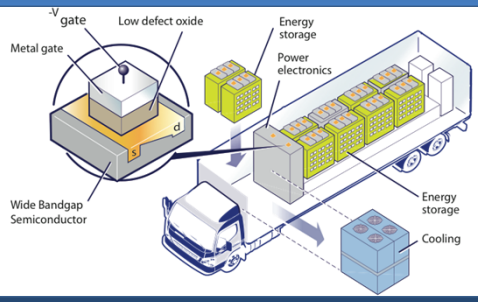
Project Overview

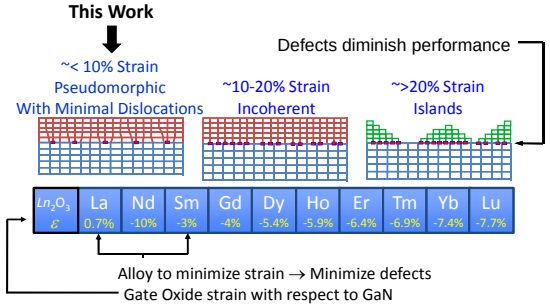


Purpose

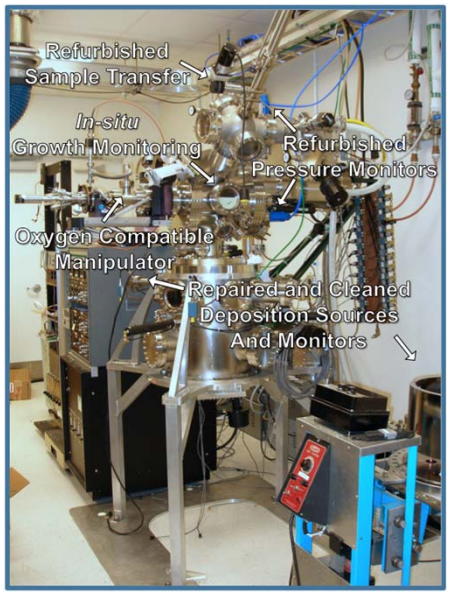
- Wide bandgap semiconductor devices such as SiC and GaN can improve the performance of existing power conversion systems used in energy storage applications.
- Wide bandgap semiconductor devices can operate efficiently at higher temperatures, can have higher switching speeds, and have longer performance life
- New devices such as SiC and GaN MOSFETs lack a suitable gate oxide – a key material that enables power switching

Methodology

- Defects in gate oxide layer can adversely affect performance and reliability:
  - Dislocations ➔ Leakage + Breakdown
  - Unsatisfied Bonds ➔ Charge traps
  - Grain Boundaries ➔ Leakage + Breakdown
- Minimizing defects will enable reliable, efficient, high-performance devices
- Ln_2O_3 oxides can be grown in low strain states on GaN and SiC



Progress



- Si-Ge MBE system converted for gate oxide growth
  - Manipulator converted for oxide compatibility
  - *In-situ* RHEED growth diagnostics added; imperative for understanding defects
  - Sources refurbished for oxide growth
- Initial oxides synthesized on GaN

Future Plans

- Synthesize new low-defect alloy oxides on GaN and SiC
- Integrate alloy oxides into test architectures to validate performance under representative conditions
- Optimize material interface to enable high performance devices

Impact on DOE OE Energy Storage Mission

Efficient and reliable power conversion system based upon GaN and SiC can enable overall increased performance and decreased cost, size, and weight resulting from decreased device cooling requirements. Key to this is the development of wide bandgap semiconductor MOSFET devices with high-quality gate oxides, which this program aims to develop.

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