

# Final Report

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**Title:** GaN MISFETs  
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**Long term goals:** Microwave signal amplification at high power levels exceeding those achieved with currently available GaN Heterostructure Field Effect Transistor Technology

## Objectives:

Conduct experimental and theoretical studies to demonstrate and analyze the advantages offered by AlN/GaN MISFETs:

- » MOCVD Growth of high-quality AlN/GaN heterostructures
- » Simulate AlN/GaN MIS structures and MISFETs
- » Develop high-power AlN/GaN MISFETs and Amplifiers
- » Characterize DC, low- and high-frequency, and power performance of AlN/GaN MISFETs

## Approach:

- Evaluate the crystalline quality of AlN/GaN heterostructures and in particular AlN through XRD
- Determine the electrical properties of MISFETs through Hall characterization and evaluate optimum designs for normal and inverted AlN/GaN heterostructures
- Study the low-frequency properties of AlN/GaN MISFETs and determine interface state properties and dispersion effects and their impact on small and large-signal device properties
- Fabricate micron and submicron AlN/GaN MISFETs devices
- Optimize the DC, small-signal, and power characteristics of AlN/GaN MISFETs through simulation and experimentation  $\Rightarrow$  determine optimum MISFET layer structures
- Design, fabricate, and characterize high-power MISFET amplifiers

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**Work Completed:**

- Evaluated the crystalline quality of AlN/GaN heterostructures and in particular AlN through XRD
- Determined the electrical properties of MISFETs through Hall characterization
- Determined the interface state properties of AlN/GaN MISFETs
- Fabricated micron AlN/GaN MISFETs devices
- Simulated the DC characteristics of AlN/GaN MISFETs

**Results:**

- XRD of MISFET structure shows distinctive AlN peak ( $d_{\text{AlN}} = 12\text{nm}$ ) indicating good crystalline quality
- AlN thickness was varied between 5 and 18nm to maximize electron mobility
- Hall mobility of overall MISFET (GaN channel and thin AlN barrier) structure increases with decreasing AlN thickness up to  $\mu = 320\text{cm}^2/(\text{Vs})$  for 11nm AlN
- The necessary process for AlN/GaN MISFETs was developed and applied to heterostructures grown by MOCVD
- The DC, low-frequency, high-frequency and small-signal characteristics of AlN/GaN MISFETs were studied experimentally and the results demonstrate good electrical performance.
- AlN/GaN MISFETs 2 $\mu\text{m}$ -long gates demonstrated  $I_{\text{DSS}}$  of 700mA/mm and extrinsic  $g_m$  of 136mS/mm
- AlN/GaN MIS demonstrate good C-V characteristics corresponding to low interface states density of  $\sim 10^{11}\text{cm}^{-2}\text{eV}^{-1}$
- Modeling and characterization confirms extremely low heterostructure interface density

**Impact/Applications:**

- Development of high power III-V Nitride MISFETs operating at high frequency responds to the needs of future generation multifunctional electromagnetic systems envisioned by the Navy and DoD
- The devices studied under this program will allow to increase the performance of radar, electronic warfare and communications systems through improved power characteristics at high frequencies.

**Transitions:** N/A

**Related Projects:** N/A

**References:** N/A

**Publications (Names of books, chapters, or significant papers as a result of award):**

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