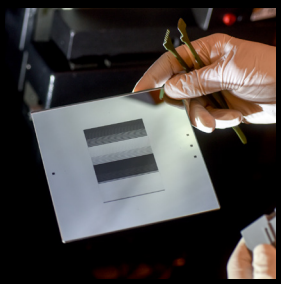
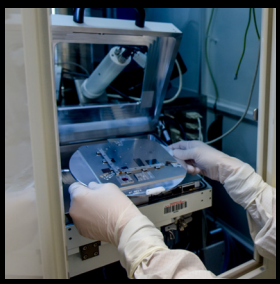
NC STATE UNIVERSITY

NNF

NCSU NANOFABRICATION FACILITY





nnf.ncsu.edu

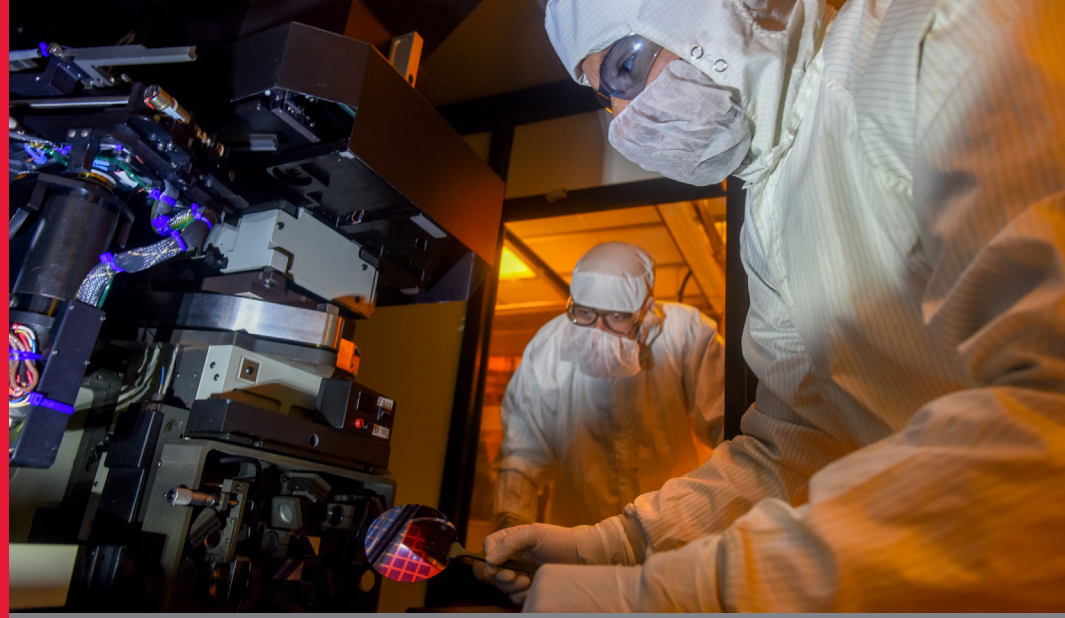
FACILITY CONTACT INFORMATION

Dr. Philip Barletta
Director of Operations
919.513.1976
pbarlet@ncsu.edu

Dr. John Muth
Director
919.513.2982
muth@ncsu.edu

Marcio Cerullo
Lab Manager
919.515.5054
mcerull@ncsu.edu

Nicole Hedges
Business and Education Manager
919.515.2809
nchedges@ncsu.edu



ABOUT THE NCSU NANOFABRICATION FACILITY (NNF)

The NCSU Nanofabrication Facility (NNF) is a Class 100/Class 1000 clean room that provides semiconductor processing capabilities to a variety of science and engineering disciplines. The facility possesses a full range of micro- and nano-fabrication capabilities including photo and electron beam lithography, wet and dry etch, chemical vapor deposition (including atomic layer deposition), vacuum metalization, rapid thermal anneal, and various characterization tools. The NNF is capable of processing on a broad range of substrates such as semiconductors, ceramics, plastics and glass with sizes from small pieces to 6" wafers.

In addition to offering affordable access to state-of-the-art semiconductor fabrication equipment, the NNF provides personalized training on operation of equipment by experienced staff, teaching laboratories for undergraduate and graduate courses, and infrastructure for design projects, workshops, tours and research experiences. It also serves as a melting pot for a community of top-notch researchers from academia, government labs and industry.

In addition to providing semiconductor fabrication capabilities to NC State and the greater research community, the NNF also prides itself on educating the next generation of scientists and engineers. Many NNF users have used their experience in the facility to jump-start their careers in small business, large industry, or academia. Some of these users have reached back to us to share how their time at NNF has prepared them for the next step in their professional journey:

"NNF is not only a research platform, it's a culture, society and the world under a building. Friendly environment, smiling faces, along with access to the state-of-the-art facilities boosts the confidence to adapt in this ever-changing world."

Biplab Sarkar, assistant professor, Indian Institute of Technology (IIT)

"As a young entrepreneur, having access to state-of-the-art facilities is crucial. I built my first prototypes at the NNF, which would have been impossible without their specialized equipment. These experiments were a cornerstone in uncovering the technical challenges and the feasibility of commercializing a new emerging technology."

Rafael Estevez, director of operations, Growers

NC STATE Engineering

"In addition to providing expertise and guidance in industry-standard nanofabrication processes, the NNF enabled my work developing novel semiconductor devices using specialized materials. That broad process flexibility afforded me hands-on experience and prepared me for a career in emerging and disruptive semiconductor technologies."

Patrick Wellenius, semiconductor process engineer, Protochips

"Performing research in the NNF prepared me to seamlessly transition into Intel's state-of-the-art process development fabrication facility. It also helped me to grow a list of professional contacts in the industry."

Erinn Needham, PTD engineer, Intel

"The knowledge and experience I gained from the NNF allowed me to land my dream job at Intel, manufacturing the next generation of CPUs."

Kory Gray, PTD engineer, Intel

"My time at NNF was some of the most influential of my life to be honest. It was just a lot of fun! The most positive part of NNF was the staff. I was privileged to learn from incredibly talented people like Marcio Cerullo and Nicole Hedges… they had a tremendous influence on my life. Overall, it's a great university and research fab with solid process capability and I had a fantastic time there."

Chris Hardiman, process development engineer, Wolfspeed

CAPABILITIES

THERMAL PROCESSING
- Rapid thermal annealing up to 1300˚C
- Steam and dry oxidation up to 1100˚C
- Phosphorous and boron doping

PLASMA ETCHING
- Wide variety of process gases available
  - Ar, O_2, SF_6, CH_4, CHF_3, C_2F_6 , C_4F_8
- Designated nitride etch system
  - BCl_3, Cl_2 process gases
- Bosch process Deep RIE
- Nordson MARCH O_2 asher

LITHOGRAPHY
- Contact aligner
- 5X reduction stepper
- Direct-write electron beam lithography
- Direct-write laser lithography
  - Ideal for mask making

CHEMICAL VAPOR DEPOSITION
- Atomic layer deposition (ALD)
- Low-pressure CVD
  - Si_3N_4, Polysilicon, Low Temp Oxide

PHYSICAL VAPOR DEPOSITION
- Electron beam and resistively heated metal evaporation
- DC Sputter

METROLOGY
- Optical microscopy
- Optical and contact Profilometry
- Four-Point Probe
- Ellipsometry
- Nanometrics metrology system
- Electrical/Thermal Characterization tools

GLOVEBOX
- N_2 environment with < 0.1ppm H_2O/O_2
  - Embedded spinner and resistive heated evaporator

NNF professional staff: Nicole Hedges, Phil Barletta, Jeff Ricker-Hagler, Greg Allion, Bill Kiether, Sharon Guidry, Jim Mitchell, Marcio Cerullo.

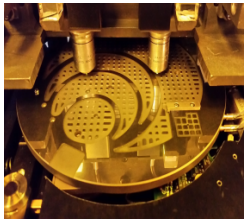
LITHOGRAPHY

PHOTOLITHOGRAPHY (PROJECTION)

1. GCA 5X Reduction i-line Stepper
- Feature sizes down to 0.6µm
- Registration better than 500nm
- Chuck design allows 10mm – 6" pieces and thicknesses from 300-900um

2. Heidelberg µP-101 Direct Write
- Sample Sizes: Pieces to 5"x 5" Samples
- Feature Sizes down to 0.8µm
- Grey scale Exposure Mode – 3-D lithography
- Mask writing ability for MA-6 masks and stepper reticles
- 375nm UV Diode Laser (good for + and - resists, including SU-8)

1



2

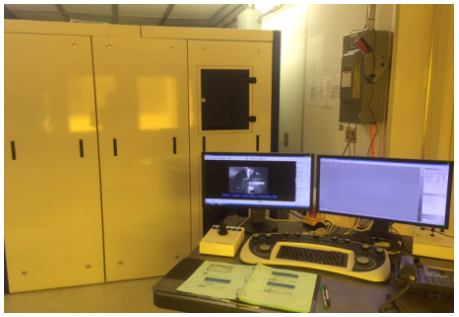
PHOTOLITHOGRAPHY (CONTACT)

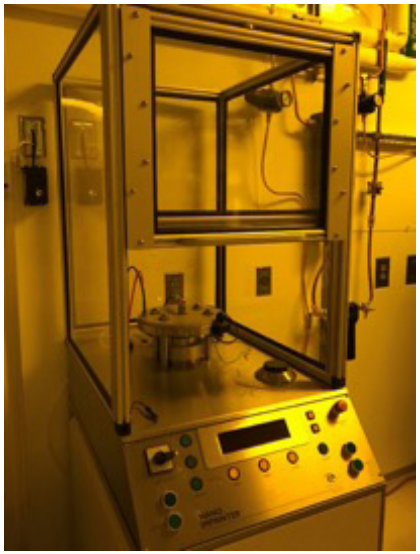
Karl Suss MA-6
- Feature Sizes down to 2µm
- 10mm pieces to 6" wafers (thicknesses of 200µm to 4mm possible)
- Front Side and Back Side Alignment
- Accepts 4", 5", and 7" masks
- 4 Sample Holders: 3" Vacuum Chuck, 4" Vacuum Chuck, 4" Wafer, 6" Wafer
- Flood, proximity, soft, hard, and vacuum contact modes available

ELECTRON BEAM LITHOGRAPHY

Raith 150 E-beam Aligner

- Feature sizes down to 20nm
- Specially designed sample holders: Pieces – 6" Wafers; rotate/tilt chuck
- Low kV exposure and imaging (SE detector with BSE detector option)
- Accelerating voltage up to 30kV
- 20-MHz digital pattern generator
- Stitching and overlay accuracy of about 35nm





NIL-2.5 Nanoimprinter

- High-throughput patterning of nanostructures
- Up to 2" diameter imprint area
- Variable time, temperature, pressure
- Tmax = 250°C, Pmax = 70 bar
- Low cost, relatively simple alternative to optical and/or e-beam lithography

THERMAL PROCESSING

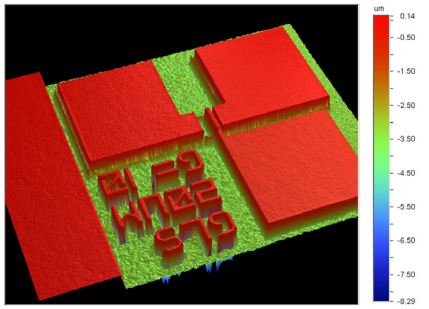
ANNEALSYS RAPID THERMAL PROCESSING

- Temperature Range: 250 - 1300°C
- Pressure Control: Vacuum - ATM
- Gas Options: N_2, Ar, N_2O, H_2/N_2
- Sample Sizes: 4" and 6" wafers; Pieces on carrier

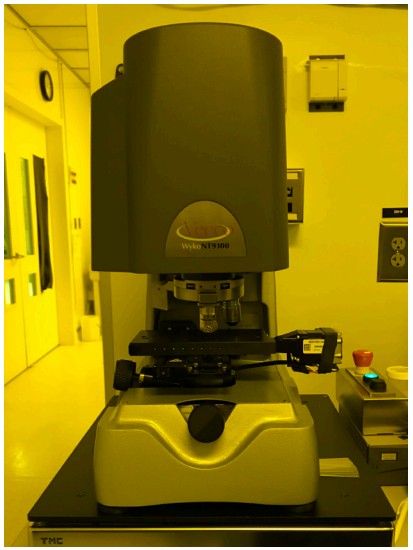
METROLOGY

PROFILOMETRY

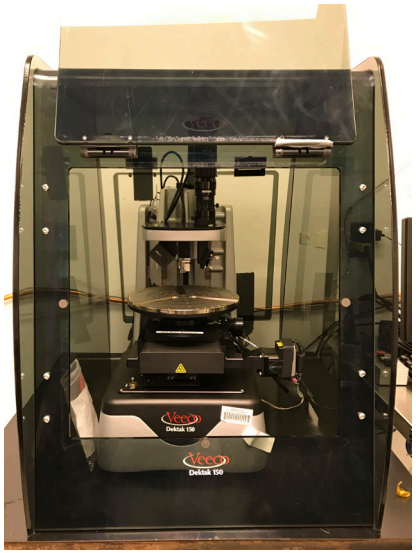
- Both optical and contact profilometry available
- Wyko offers area imaging capabilities
- Step height, surface roughness
- Dektak capable of step height measurements up to 1mm
- Also capable of stress measurement



Optical profilometry image of GaN FET gate metal.



Wyko NT 9100

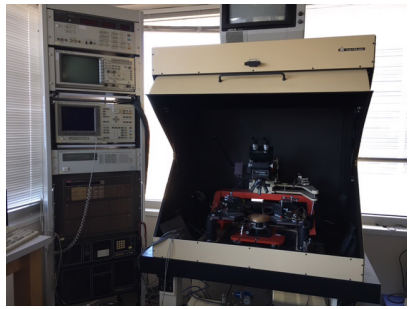


Dektak 150

ELECTRICAL CHARACTERIZATION

Probe Station

- HP 4280A 1MHz C Meter/C-V Plotter
- HP 54520A 500MSa/s 500MHz Oscilloscope
- HP 4156A Precision Semiconductor Parameter Analyzer
- HP 6623A System DC Power Supply



THIN FILM DEPOSITION

ATOMIC LAYER DEPOSITION (ALD)

Ultratech ALD

- Enables conformal atomic layer deposition of various materials
- Oxides: Al_2O_3, HfO_2, and SiO_2
- Nitrides: AlN, Si_3N_4
- Sample Sizes: 8" diameter and smaller
- Deposition temperature: 100°C ~ 400°C

PLASMA ETCHING

III-V ETCH CAPABILITIES

1. Oxford PlasmaLab 100

- Gases: BCl_3, Cl_2, SF_6, O_2, Ar, N_2 + capacity for several others
- Ideal for GaN-based HEMTs and blue-green LED structures

DEEP RIE (REACTIVE ION ETCH)

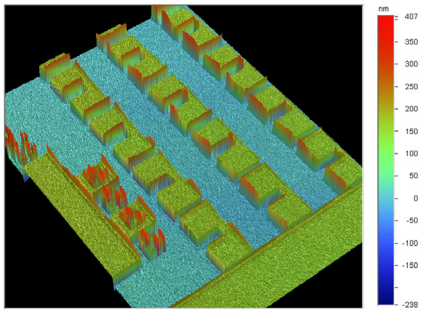
2. Alcatel AMS100 DRIE

- Utilizes Bosch process
- Ideal for high aspect ratio etches

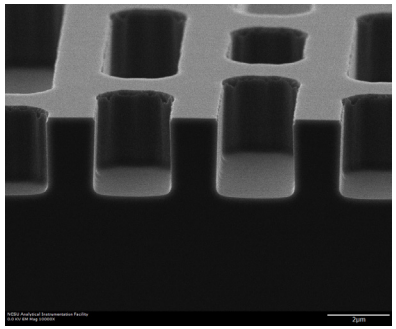
SILICON ETCH

3. Oxford NGP80

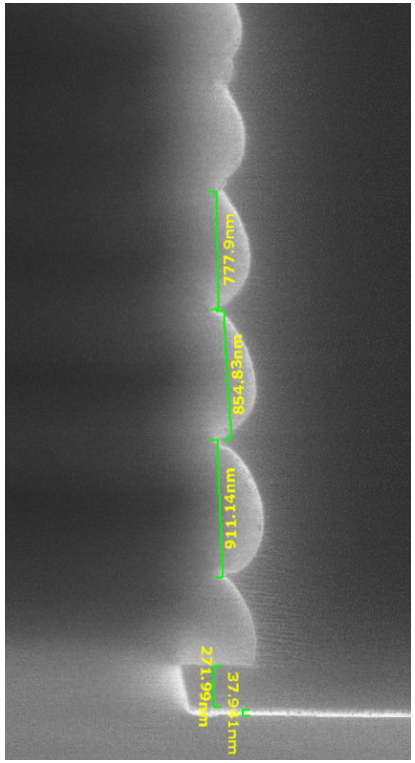
- Process gases available: CF_4,CHF_3, C_2F_6, SF_6, O_2, Ar
- Ideal for dry etching of Si, SiC, SiO_2, Si_3N_4, and polymers



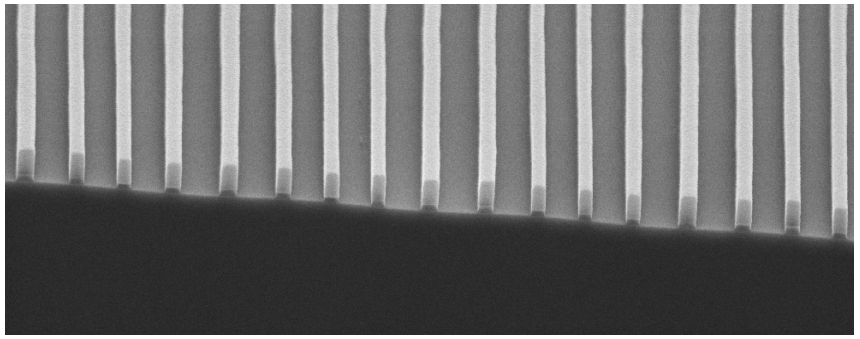
Optical profilometry image of GaN FET mesas etched via BCl_3 / Cl_2 plasma process.



High aspect ratio trenches etched into silicon substrate using SF_6 / C_4F_8 plasma process.



Sidewall profile of trenches etched into silicon substrate using SF_6 / C_4F_8 plasma process.



Pattern etched into silicon substrate using SF_6 plasma.


OCS-10.0X
10.0MP
S/N KC110307179
BACK REFLECTION
CONTROL
microscope
SOLUTIONS
(800) 231 - 7910
Maintenance Service
Calibration

National
Nanotechnology
Coordinated
Infrastructure

NNF is a member of the Research Triangle Nanotechnology Network (RTNN) and the National Nanotechnology Coordinated Infrastructure (NNCI).

nnf.ncsu.edu

@NCStateNanoFab