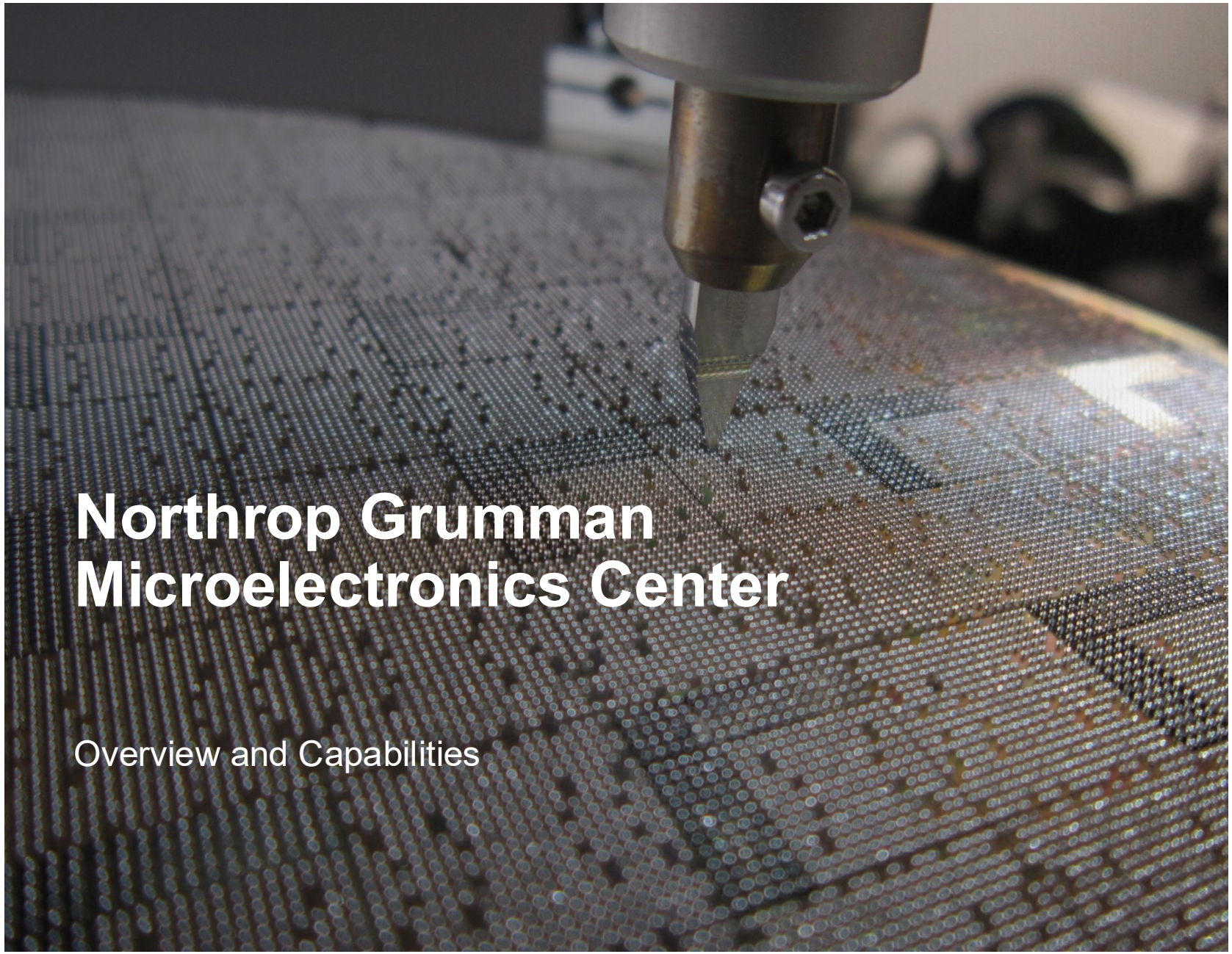


Northrop Grumman Microelectronics Center

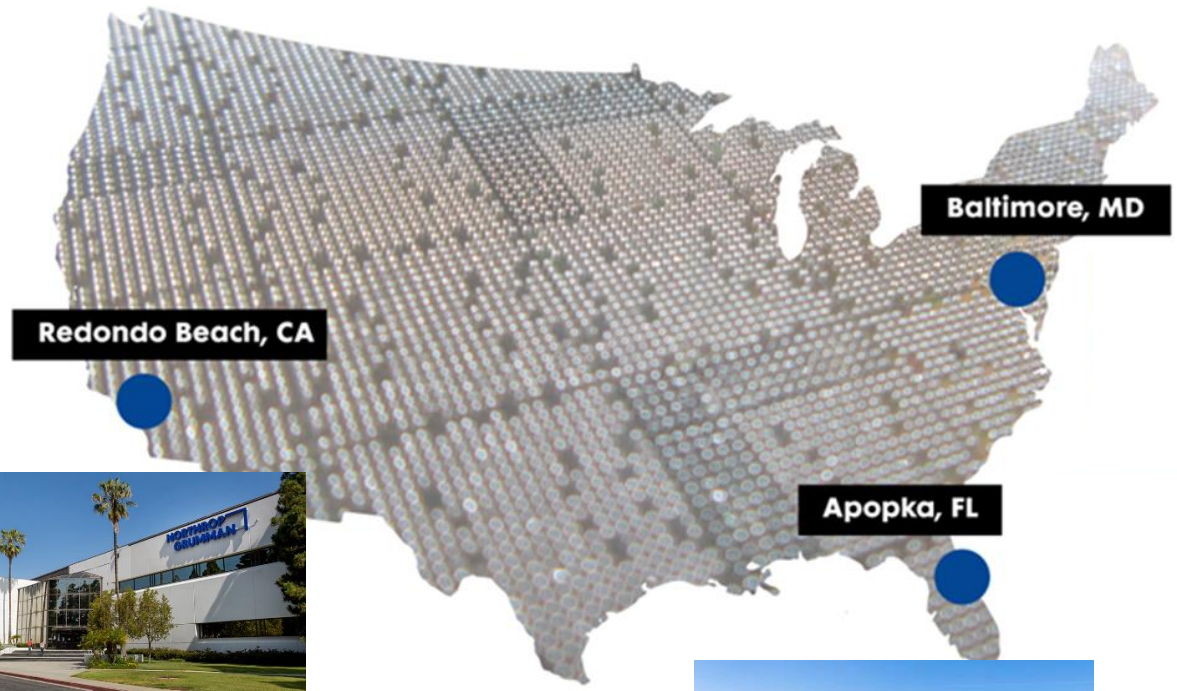
Overview and Capabilities

Louise Sengupta
Director
Northrop Grumman Microelectronics Center

Northrop Grumman Microelectronics Center (NGMC)

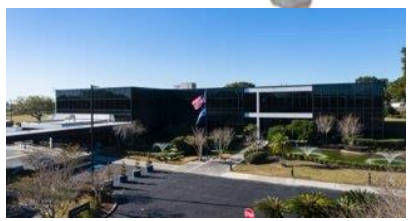
Effective in 2024, NG is Providing Open Access to its Microelectronics Capabilities

- Integrated Multifunction Sensing
- Quantum Science
- Future-G Wireless Technology
- Advanced Materials
- Space & Rad Hard Technologies
- Renewable Energy Generation and Storage
- Advanced Computing
- Human-Machine Interfaces
- Directed Energy
- Hypersonics



Space Park Foundry
- *Compound Fab & Space Advanced Packaging*

Advanced Technology Laboratory
- *Silicon, Compound, & Specialty Device Fab*
- *Advanced Testing*
- *Wafer Post-Processing*
- *2D, 2.5D & 3D Advanced Packaging*



Apopka µ-Line
- *Wafer Post-Processing (Bump, Dice, Test)*

NGMC Capabilities and Strategic Partnerships Provide Flexible, Assured Microelectronics for Commercial and Defense Industrial Base Companies

Trends We See Within the Domestic Microelectronics Base and the Northrop Grumman Microelectronic Center Solution

NORTHROP GRUMMAN

Mil / Aero Needs

- High Mix / Low Volume over many years
- Performance, SWaP, reliability driven
- Secured / Trusted / Assured sourcing

Commercial Supplier Gaps

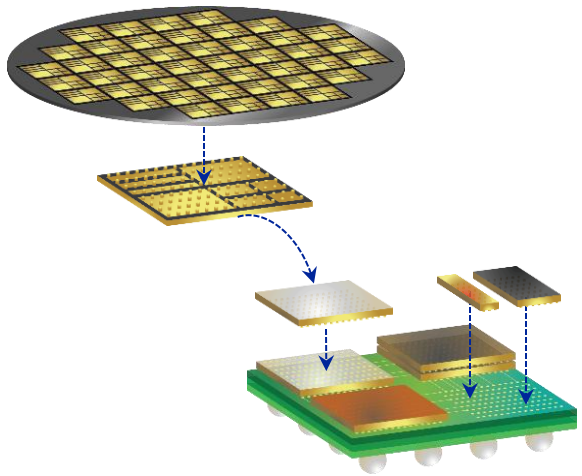
- High-volume low-mix focus
- International / ITAR
- Rapid product change

Overarching Gaps

- Technical knowledge base
- IP protection
- Secure & Trusted supply
- Rapid DMS vs. long-term stability

Domestic Supplier Gaps

- Limited capability / capacity
- Investment business-case
- Fed-Ex Flow, no 1-stop shop



NG's Microelectronics Development, Solutions and Products Are Based on USG System Needs

NGMC Offers Our Assured And Long-Term Access To USG Microelectronics Technologies

NGMC Access Could Be For a Single Service(s) or End-to-End Microelectronics Solutions

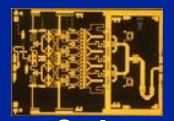
NGMC Access Includes Listed Products, Tape Out Unique Designs, New Product Development, Testing, Post-Processing And Product Engineering

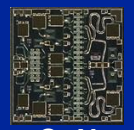
NGMC Open Access Offerings

Northrop Grumman Fills the Microelectronics Gaps Across the Domestic Industry

NG Has Extensive Experience Working With A Mix of NG & Commercial Suppliers As Part Of A Value Chain

Enabling Microelectronics


GaAs


GaN


InP


SLCFET


SiGe


CMOS


DROIC

Design & Layout

- Design Support Into Both Domestic Commercial Fabs & NG Fabs

Silicon

- Access to NG's Analog & Mixed Signal Harden Technologies

Compound Semi

- Access to NG's Unique RF and High-Power Devices Tuned To Unique USG Program Needs

Advanced Test

- Wafer, Die, Interposer, & Advanced Packaging Testing of Product From Most Domestic Fabs Including First Article Development & Test Time Reduction

Wafer Post Processing

- Post Processing for Chip & Wire, 2D, 2.5D & 3D Including Challenging Materials

Advanced Packaging

- 100mm – 300mm Bumping (Copper, Lead, Eutectic & Pb-Free)

Product Engineering

- End-to-End Yield & Product Control for Product Line Heath Monitoring and Yield Improvement

NGMC Open Access Offerings

Northrop Grumman Fills the Microelectronics Gaps Across the Domestic Industry

Design & Layout

- Aggression (MPW) & Layout Services
- NGMC's Fabs
- GlobalFoundries™
- Intel™
- TowerJazz™
- Texas Instruments™
- Qorvo™
- Wolfspeed™
- M/ACOM™
- Skywater™

Silicon

- 10V, 15V, 40V & 60V Radiation Harden BiCMOS
- 0.5um & 0.8um Radiation Harden CMOS w/ Volatile Memory (NVM)
- Radiation Harden EEPROMs
- L-Band & S-Band Bipolar Power SiGe Transistors
- Charge Coupled Devices (CCD)
- Superconducting Electronics (SCE)

Compound Semi

- 0.15 & 0.1um GaAs HEMT
- 1.0um GaAs HBT
- 0.2, 0.15 & 0.09um PWR GaN HEMT
- 0.15um LNA GaN HEMT
- 0.1um InP HEMT
- 70, 35 & 25nm InP IACC
- 0.8 & 0.65um InP TF
- SiC 100V Schottky SIT Power Trans.
- -20 & -14V SLCFET Switches & Diodes
- 2.5 – 15V SLCFET Amplifiers (LNAs & HPAs)

Advanced Test

- 6", 8" & 12" Wafer & Die-Level Digital ASIC (180nm – 5nm) Testing
- 6", 8" & 12" RFIC Wafer & Die-Level Testing
- Bare Pad & Bumped Film Frame Wafer, Singulated Wafer & Die-Level Testing
- Interposer (Wafer, Glass & Organic) Testing
- 2D, 2.5D & 3D Package Testing
- Classified (SCI & SAP) Options
- Reliability & Environmental Testing

Wafer Post Processing

- Mechanical & Laser Wafer Dicing
- Mechanical Wafer & Die Grinding
- Wire Bonding
- Environmental Testing: HAST, Leak, Centrifuge, RF Shield
- Die Marking & Traceability
- Gel, Waffle and Tape & Reel

Advanced Packaging

- 100mm – 300mm Lead, Eutectic & Pb-Free Solder Sphere Drop Based Wafer Bumping
- 100mm – 300mm Copper Plated Bumps and Pillars Bumping
- Under Bump Metallization (UBM)
- 2D & 3D Automatic Optical Inspection (AOI)
- 2D, 2.5D & 3D Die – Wafer Assembly
- Chip Scale Hermetic Packaging

Product Engineering

- New Product Development
- IP Protection Controls
- Post Test Analysis Screening
- Product Line Heath Monitoring
- Yield & Quality Management (including through FedEx Flow)
- Qualification Plan Development
- Document Configuration
- Product Disposition

NGMC Open Access Offerings – Example Usage of NGMC

To Address a Low-Band Radar

Design & Layout	Silicon	Compound Semi	Advanced Test	Wafer Post Processing	Advanced Packaging	Product Engineering
Aggression (MPW) & Layout Services	10V, 15V, 40V & 60V Radiation Harden BiCMOS	0.15 & 0.1um GaAs HEMT	6”, 8” & 12” Wafer & Die-Level Digital ASIC (180nm – 5nm) Testing	Mechanical & Laser Wafer Dicing	100mm – 300mm Lead, Eutectic & Pb-Free Solder Sphere Drop Based Wafer Bumping	New Product Development
NGMC’s Fabs	0.5um & 0.8um Radiation Harden CMOS w/ Volatile Memory (NVM)	1.0um GaAs HBT	6”, 8” & 12” RFIC Wafer & Die-Level Testing	Mechanical Wafer & Die Grinding	100mm – 300mm Copper Plated Bumps and Pillars Bumping	IP Protection Controls
GlobalFoundries™	Radiation Harden EEPROMs	0.2, 0.15 & 0.09um PWR GaN HEMT	Bare Pad & Bumped Film Frame Wafer, Singulated Wafer & Die-Level Testing	Wire Bonding	Under Bump Metallization (UBM)	Post Test Analysis Screening
Intel™	L-Band & S-Band Bipolar Power SiGe Transistors	0.15um LNA GaN HEMT	Interposer (Wafer, Glass & Organic) Testing	Environmental Testing: HAST, Leak, Centrifuge, RF Shield	2D & 3D Automatic Optical Inspection (AOI)	Product Line Heath Monitoring
TowerJazz™	Charge Coupled Devices (CCD)	0.1um InP HEMT	2D, 2.5D & 3D Package Testing	Die Marking & Traceability	2D, 2.5D & 3D Die – Wafer Assembly	Yield & Quality Management (including through FedEx Flow)
Texas Instruments™	Superconducting Electronics (SCE)	70, 35 & 25nm InP IACC	Classified (SCI & SAP) Options	Gel, Waffle and Tape & Reel	Chip Scale Hermetic Packaging	Qualification Plan Development
Qorvo™		0.8 & 0.65um InP TF	Reliability & Environmental Testing			Document Configuration
Wolfspeed™		SiC 100V Schottky SIT Power Trans.				Product Disposition
M/ACOM™		-20 & -14V SLCFET Switches & Diodes				
Skywater™		2.5 – 15V SLCFET Amplifiers (LNAs & HPAs)				

NGMC Open Access Offerings – Example Usage of NGMC

To Address a Space Payload

Design & Layout

- Aggression (MPW) & Layout Services
- NGMC's Fabs
- GlobalFoundries™
- Intel™
- TowerJazz™
- Texas Instruments™
- Qorvo™
- Wolfspeed™
- M/ACOM™
- Skywater™

Silicon

- 10V, 15V, 40V & 60V Radiation Harden BiCMOS
- 0.5um & 0.8um Radiation Harden CMOS w/ Volatile Memory (NVM)
- Radiation Harden EEPROMs
- L-Band & S-Band Bipolar Power SiGe Transistors
- Charge Coupled Devices (CCD)
- Superconducting Electronics (SCE)

Compound Semi

- 0.15 & 0.1um GaAs HEMT
- 1.0um GaAs HBT
- 0.2, 0.15 & 0.09um PWR GaN HEMT
- 0.15um LNA GaN HEMT
- 0.1um InP HEMT
- 70, 35 & 25nm InP IACC
- 0.8 & 0.65um InP TF
- SiC 100V Schottky SIT Power Trans.
- -20 & -14V SLCFET Switches & Diodes
- 2.5 – 15V SLCFET Amplifiers (LNAs & HPAs)

Advanced Test

- 6", 8" & 12" Wafer & Die-Level Digital ASIC (180nm – 5nm) Testing
- 6", 8" & 12" RFIC Wafer & Die-Level Testing
- Bare Pad & Bumped Film Frame Wafer, Singulated Wafer & Die-Level Testing
- Interposer (Wafer, Glass & Organic) Testing
- 2D, 2.5D & 3D Package Testing
- Classified (SCI & SAP) Options
- Reliability & Environmental Testing

Wafer Post Processing

- Mechanical & Laser Wafer Dicing
- Mechanical Wafer & Die Grinding
- Wire Bonding
- Environmental Testing: HAST, Leak, Centrifuge, RF Shield
- Die Marking & Traceability
- Gel, Waffle and Tape & Reel

Advanced Packaging

- 100mm – 300mm Lead, Eutectic & Pb-Free Solder Sphere Drop Based Wafer Bumping
- 100mm – 300mm Copper Plated Bumps and Pillars Bumping
- Under Bump Metallization (UBM)
- 2D & 3D Automatic Optical Inspection (AOI)
- 2D, 2.5D & 3D Die – Wafer Assembly
- Chip Scale Hermetic Packaging

Product Engineering

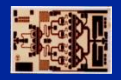
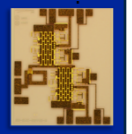
- New Product Development
- IP Protection Controls
- Post Test Analysis Screening
- Product Line Heath Monitoring
- Yield & Quality Management (including through FedEx Flow)
- Qualification Plan Development
- Document Configuration
- Product Disposition

Key NGMC Technology Capabilities

Driven By Over 2,000 Microelectronics Experts

ATL Production Technologies

Supporting >70 RF Systems Supporting Space, Air, Cyber, Maritime and Ground Systems

- 100 mm GaAs - InGaP HBT, pHEMT
- 100 mm GaN SLCFET Switch & Filters
- 150 mm Silicon
  - CMOS* (180nm, 0.5µm, 0.8µm, & 1.25µm)
  - BiCMOS (10V*, 15V, 40V*, 60V)
  - SONOS Non-Volatile Memory*
  - SiGe Bipolar Power
  - Imaging – ITO CCD

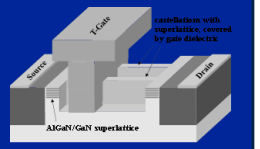
- 100 mm SiC - Schottky SIT and Ion Implanted SIT

Radiation Hardened options available

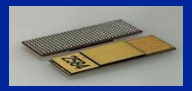
Emerging Technologies

Supporting Next Gen System Insertions

- Superconducting RQL
  - Digital Computing



- SLCFET Reconfigurable and W-band
  - Amplifiers
- Diamond Electronics
- Acoustic Filters
- Strained Layer Superlattice Detectors



External Foundry Test

Supporting Advanced Testing

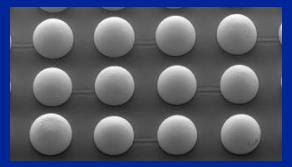
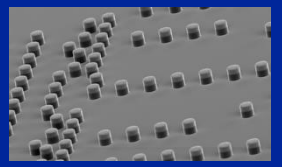
- Multi-Chip Interposer Module Testing (IPA)
- Bumped Die / Film Frame Testing
- RFIC & ASIC Wafer Testing

Advanced Packaging Technologies

Wafer Post-Processing (Apopka)

Supports Mission & Space Systems

- Nation's only domestic one-stop shop for bump/dice/test
- 100, 200, 300 mm wafers – Si, SiGe, GaN, etc.
- Lead and lead-free solder bumping + Cu-pillars
- Copper pillars for 100 mm
- Mechanical wafer dicing & thinning
- 200/300mm wafer test – extension of ATL for production
- Domestic leader in 3D automated wafer inspection
- 200/300mm automation & capacity expansion in progress

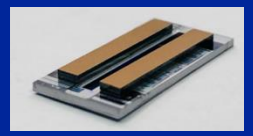



2/3D Assembly (Baltimore)

Advanced prototyping to production for NG package assemblies across RF & EO/IR domains

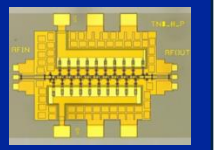
- Dedicated AP Cell within the new NG SALT facility
- R&D to production for advanced flip-chip assembly
- Pick/place/reflow + high accuracy thermocompression bond
- Advanced underfill
- High-throughput BGA attach
- Laser depanel for organic substrates



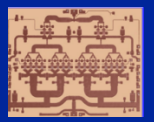


Space Park Production Technologies

Supporting Space, Air, Maritime and Commercial Programs. All technologies are Rad Hard



- GaAs HBT, HEMT
- InP HBT (TFx)
- InP HEMT (N60D/E, IACC70, IACC35/25)
- GaN Power (0.2um, 0.15um, 90nm, 50nm)
- GaN High Survivability LNA (0.15um)



- SAW Filters
- Substrates (Alumina, Quartz, BeO)
- Limiters (GaAs+, GaN, Plasma)
- NLTL (Harmonic Generation to 100 GHz)

Advanced Packaging

- Wafer Level Packaging (GaAs*, GaN*, InP)
- Diverse Accessible Heterogeneous Integration (DAHI) for Passive, Mixed Signal, Photonic and Digital Applications
- SiC Interposers
- Reliability without Hermeticity (RWOH)
- Chiplet Processing

*** 2-level qualified for Space**

Emerging Technologies

Supporting Next Gen System Insertions

- Ultra Wide Band Gap Semiconductors (e.g. AlN)
- Space Power Conversion Electronics
- LINRFET (Low loss switches and high-linearity amplifiers)
- Compact Tunable Filters
- Transferred Epitaxial Layers
- Microelectronics-based High Power Lasers

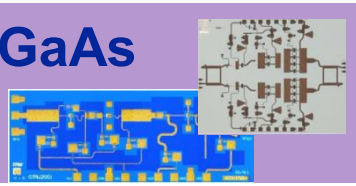
Space Park Foundry

Trusted Microelectronics

- *Over 200 engineers and technicians*
- *Class 10 cleanroom 11,700 ft² with additional 3000 ft² of Class 1000 cleanroom*

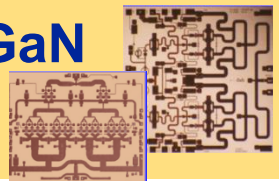
Discriminating Capabilities

GaAs



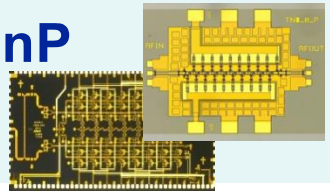
- *RF, microwave, mixed signal, digital*

GaN



- *High power SSPAs*
- *Survivable LNAs*

InP

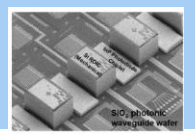


- *Wide band LNAs/PAs*
- *SC Modulators*
- *Frequency sources*

Wafer Level Packaging

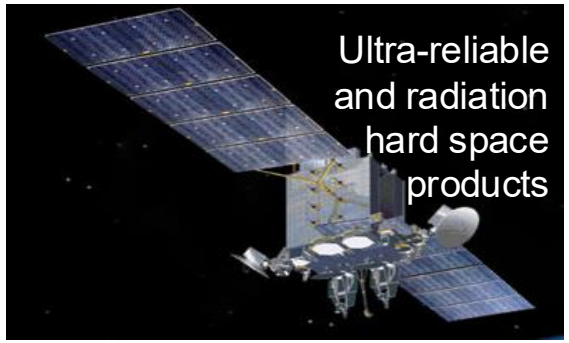
- *All RF products*
- *Wideband Phased arrays*

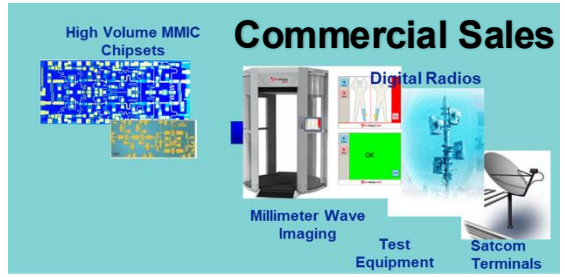
DAHI



- *Wideband flexible systems*
- *System on a Chip*

Mission Enabling Performance





Space Park is a leader in III-V semiconductor development and manufacturing

NGMC Microelectronics Technologies – Space Park

** Space Qualified
* Commercially Qualified

	Key Applications	Key Discriminators	Mission
GaAs • 0.15 um HEMT TRL= 9** • 0.1 um HEMT TRL = 9** • 1.0 um HBT TRL = 9 **	• *RF, microwave, mixed signal, digital*	• *Flight qualified* • *Mission Proven* • *TRL 9*	• *EW* • *Comms* • *ISR*
GaN • 0.2 um PWR HEMT TRL= 8* • 0.15 um LNA HEMT TRL = 8** • 0.15 um PWR HEMT TRL = 8* • 0.09 um PWR HEMT TRL = 6	• *High power SSPAs* • *Survivable LNAs*	• *High frequency, high PAE, wide bandwidth* • *High reliability*	• *EW/EA* • *Comms*
InP • 0.1 um HEMT TRL= 9** • 70, 35, 25 nm IACC TRL = 6 • 0.8 um TF2 TRL = 8 • 0.65 um TF4 TRL = 8	• *LNAs* • *SC Modulators* • *WB ADC, DAC*	• *Lowest Noise* • *Highest Freq* • *Lowest Power (dB/mW)*	• *Electronic Support* • *Array Rx*
Wafer Level Packaging • GaAs/GaAs TRL= 8** • GaN/SiC TRL = 8** • InP/InP TRL = 7 • GaAs/InP TRL = 7 • SiC Interposer TRL = 4	• *Air and Space* • *All RF products* • *Wideband Phased arrays*	• *Hermetic Micro-package* • *Lowest size / weight / cost*	• *Affordability* • *Array Rx*
3DHI • CMOS/InP TRL= 5 • CMOS/InP/GaN TRL = 4 • WLP/WLP TRL = 4 • GaAs/GaAs TRL = 5	• *Wideband flexible systems* • *System on a Chip*	• *Si, InP, GaN, … on single chip* • *NGAS is sole DAHI Foundry*	• *Array Rx / Tx*

NGMC Microelectronics Technologies – Baltimore

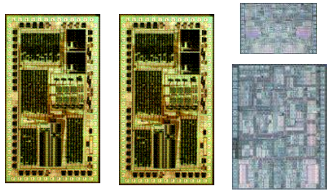
ATL Advanced Technology Laboratory

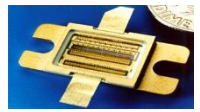
ATL Is Unique – No Other Facility In The United States Has As Large a Variety Of Semiconductor Technologies Under One Roof

High Mix / DoD-Volume Microelectronics

- Super Conducting Electronics
- GaAs HBT
  GaAs MESFET
- Silicon ASICS
  Controllers
  Regulators
  CCDs
  NVM EEPROM
  Rad-Hard ASICs
- SiC Power
  Si/SiGe Power
- GaN SLCFET
- Ultra-Wide Bandgap

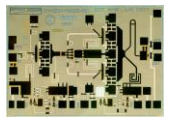
ATL produces >1 Million chips per year for F-35, SABR, G/ATOR and other NGC RF programs



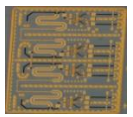


Si, SiGe, SiC RF Power Transistors (VHF to S-Band)

Si ASIC Controllers, Power Regulators/Fault Isolators, Space Qualified EEPROMs, A/D Converters, CCD Imagers



GaAs (InGaP) HBT Low Phase Noise, High TOI MMICs
GaAs pHEMT MMICs



GaN SLCFET T/R switches, High performance switched Filters

NGMC Microelectronics Technologies – Baltimore

Taking Wafers, Die and Multi-Chip Modules from Outside Entities and Performing Advanced Testing

Multi-Chip Interposer Module Testing (aka: IPA)

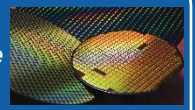
- *Automated handling capability (semi and fully auto) for high throughput*
- *Test development cost savings through integration of test SW and database from wafer to assembled device*
- *Test cost reduction with leveraging commercial ATE, RF & digital integrated test platforms*
- *Full End to End (RF to Bits) testing capability (development to start in 2023)*

Bumped Die / Film Frame Testing

- *Bumped Flip Chip, Diced Wafer on Film Frame probing*
- *8”/12” Film Frame fully automated prober with self alignment*
- *Final AOI, Bake, Tape & Reel or Gelpak packaging*

RFIC & ASIC Wafer Testing

- *PNAX-based RF testing w/ integrated digital interface*
- *Commercial ATE for high I/O and clock speed*
- *8”/12” wafer auto wafer inspection & probing*



ATL Product Engineering Services

- **Production Configuration**
  - •PSAF
  - •Trip Ticket
- **Lot Summary Report**
  - •Yield Data/Monitor
  - •Parametric Data Analysis
  - •WAT data correlation
  - •Incident History
- **Process Excursion Management**
  - •Supplier RCCA technical support (w/w Category Mgt & QME)
  - •Access to supplier defect analysis library
- **Other Engineering Services**
  - •Qualification HW Design & Testing
  - •Cleaning, Dicing & Inspection Expertise

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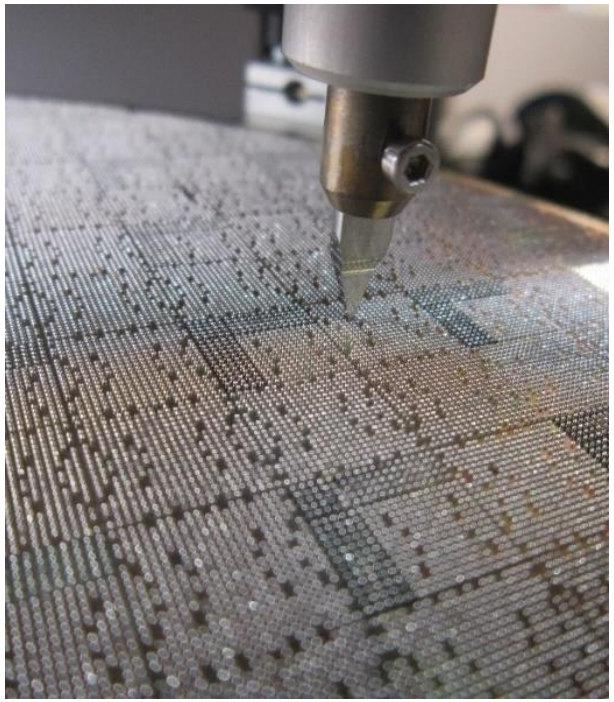
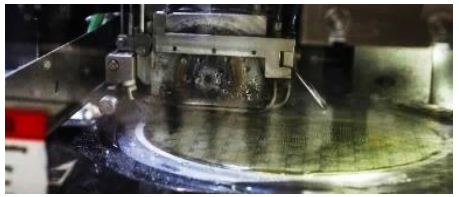
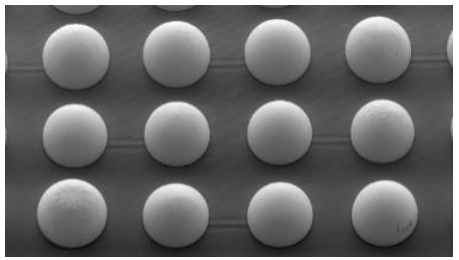
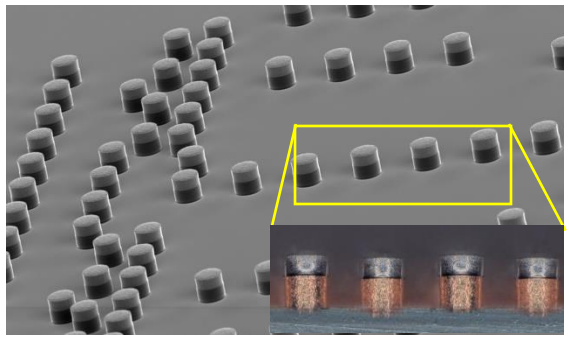
NGMC µ-Line for Wafer Post-Processing

Domestic Wafer Post-Processing Capabilities Accessible Onshore







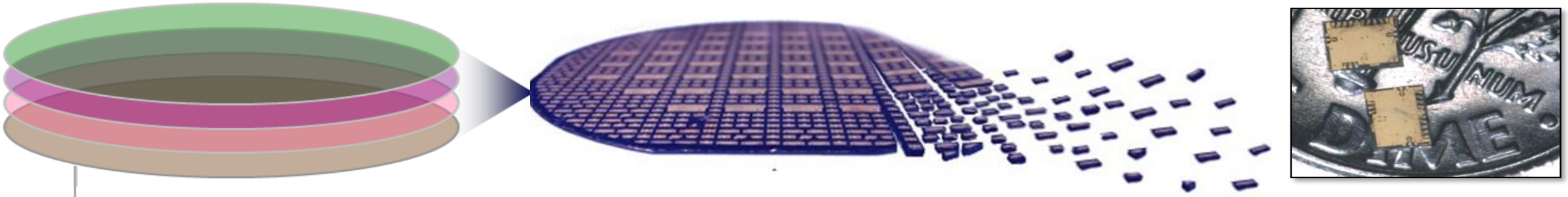


µ-Line is tailored to meet diverse post-processing needs in a flexible one-stop shop

- Sources wafers from both NG Fabs and external domestic commercial Fabs (GF, Tower, Skywater, etc.)
- 100-300 mm wafer backend processing – passivation, bump, dice, test, & inspection
- Fills domestic bumping capabilities gaps for unique USG/DoD needs
- State-of-the-art 2D/3D automated optical inspection
- Capacity & automation expansion currently underway

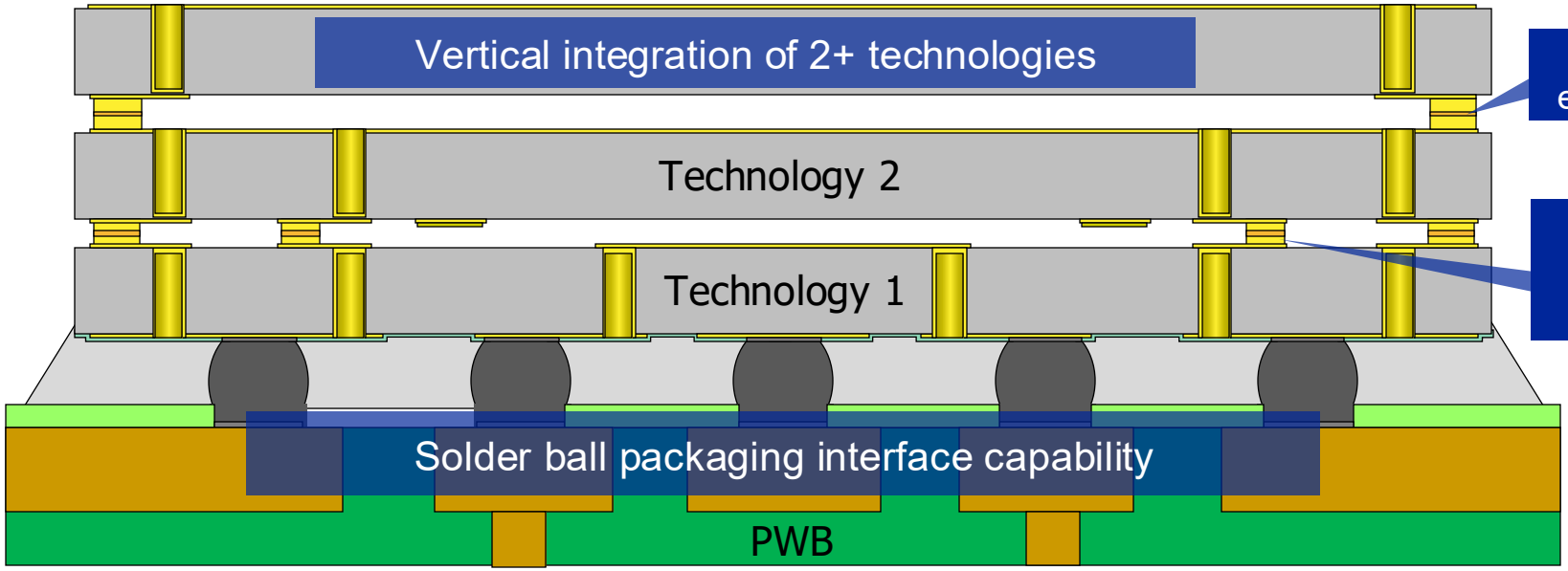
NGMC Wafer-Level Packaging

Wafer Technologies → **Precision Alignment & Bonding** → **Hermetic Self-Packaged Die**



- **Active**
  - GaAs
  - GaN
  - InP
  - Silicon
- **Passive**
  - Glass, Quartz
  - Organic
  - SiC
  - Silicon

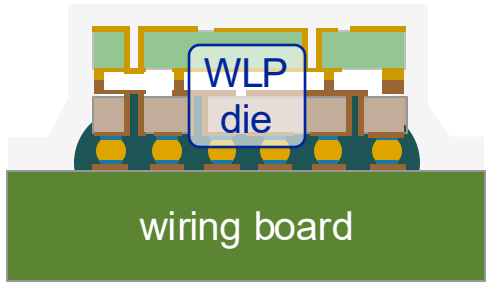
WLP Key Features & Capabilities

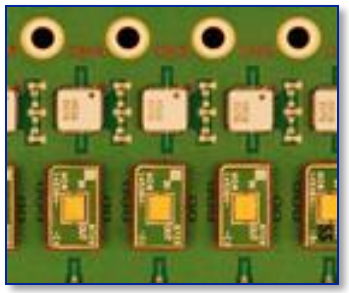


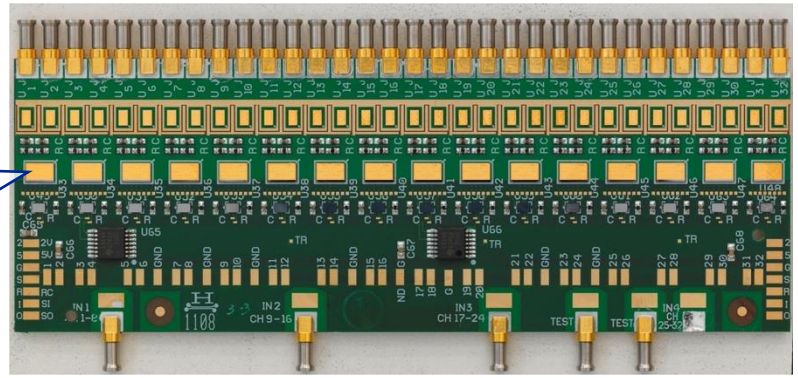
- Hermetic seal provides environmental protection
- Intra-Cavity Inter-Connects (ICICs) route signal and heat flow

Wafer-Level Packaging Applications

Direct Integration to Board







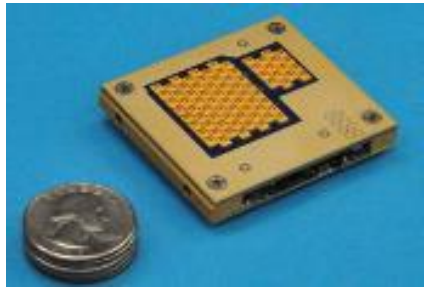
Multiple Technology Integration

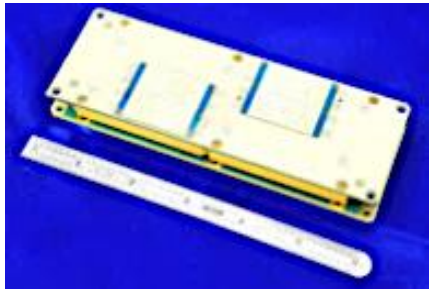
ABCS HEMT
LNA

InP HBT
PA & control

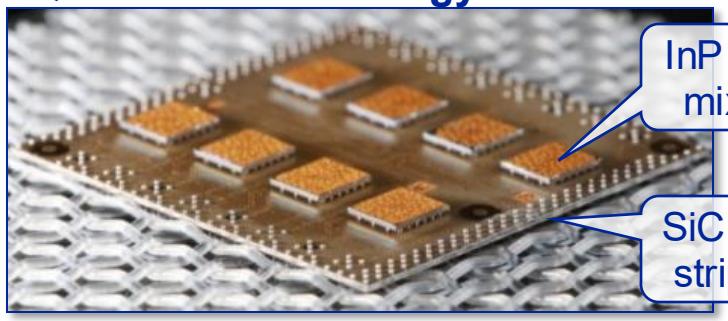
GaAs HEMT
PS & Switches

Tiled Phased Arrays

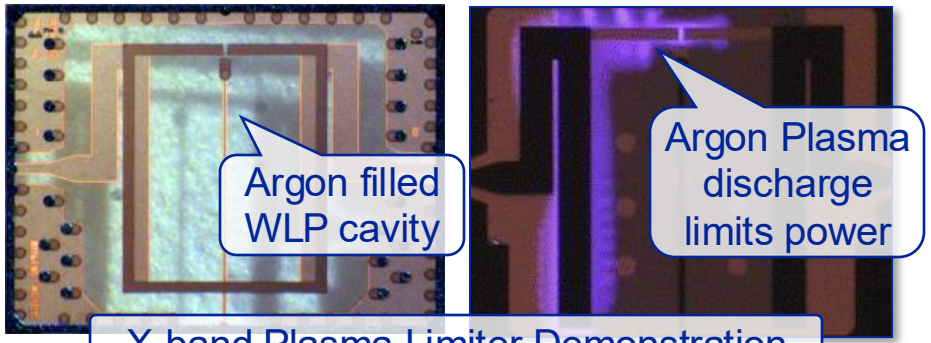




High Q Passive Technology

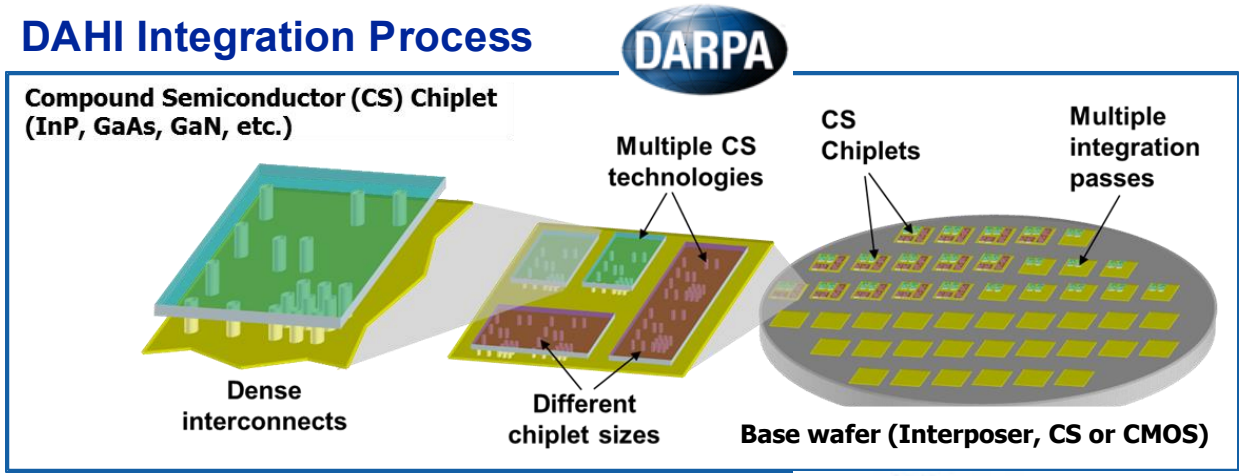


Microscale Plasma Devices

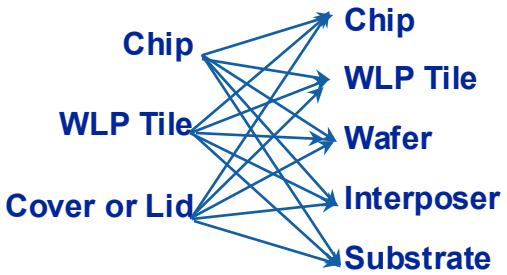


NGMC 3D Heterogeneous Integration

DAHI Integration Process

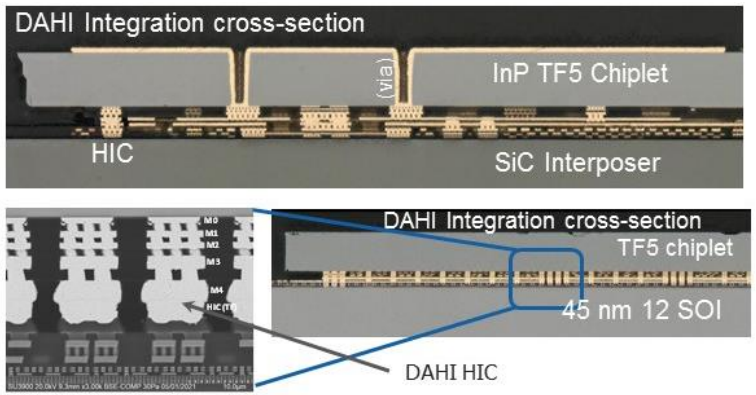


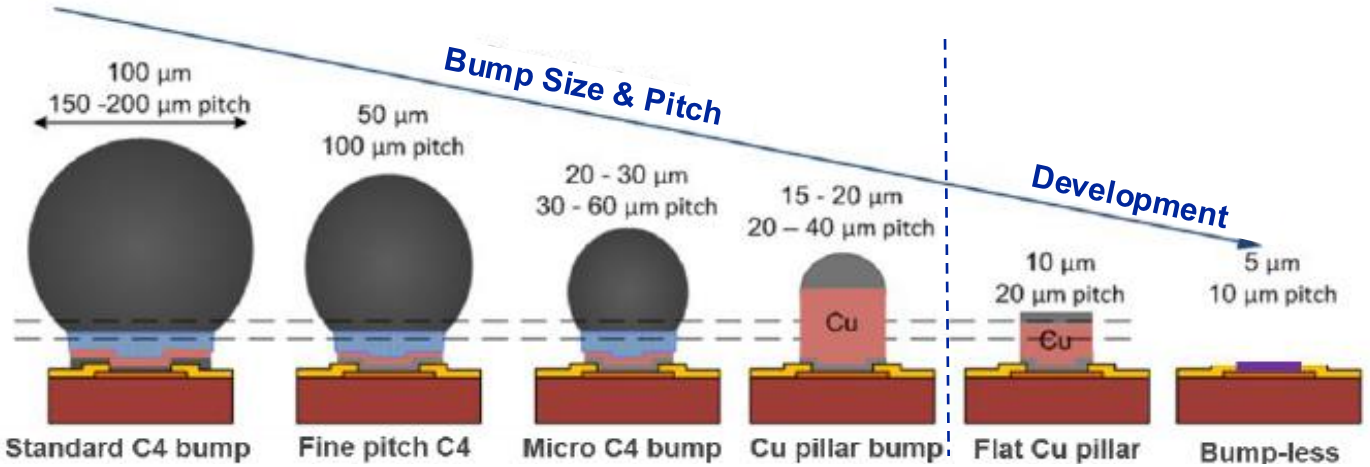
DAHI Integration Options



Au/Au bond

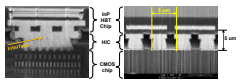
- No dendritic or whisker formation
- High thermal conductivity
- Low thermal resistance
- Malleable/ductile (as opposed to brittle solder compounds)





Au-Au DAHI HIC

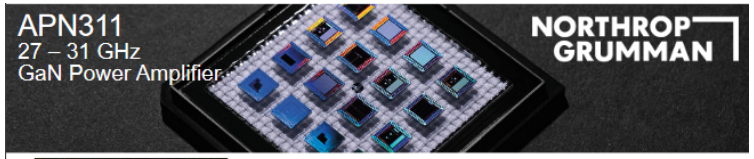
9um, 15 um pitch

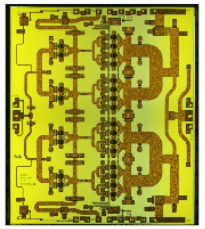


DAHI HIC

Heterogeneous integration (HI) technology enables lower cost, reduced size and weight, and enables higher performance

NGMC Product Marketing
Product Data Sheets and Web Presence





x=3.30mm; y=4.10 mm

Product Features

- RF frequency: 27 to 31 GHz
- Linear Gain: 20 dB typ.
- Psat: 45.6 dBm typ.
- Die Size: 13.52 sq. mm.
- 0.2um GaN HEMT Process
- 4 mil SiC substrate
- DC Power: 28 VDC @ 2.64 A

Applications

- Point-to-Point Digital Radios
- Point-to-Multipoint Digital Radios
- SatCom Terminals

Product Description

The APN311 monolithic GaN HEMT amplifier is a broadband, two-stage power device, designed for use in Ka-Band communication applications such as SatCom Terminals and point-to-point and point-to-multipoint digital radios. To ensure rugged and reliable operation, HEMT devices are fully passivated. Both bond pad and backside metallization are Au-based that is compatible with epoxy and eutectic die attach methods.

Performance Characteristics (Ta = 25°C)

Specification *	Min	Typ	Max	Unit
Frequency	27		31	GHz
Linear Gain	19	20		dB
Input Return Loss	5	12		dB
Output Return Loss	>5	10		dB
P1db (PP*)		43		dBm
Psat (PP*)	44	45		dBm
PAE @ Psat (PP*)		30		%
Max PAE (PP*)	30			%
Vd1=Vd1a, Vd2=Vd2a	20		28	V
Vg1. Vg1a		-3.56		V
Vg2, Vg2a		-3.46		V
Id1+Id1a		830		mA
Id2+Id2a		1860		mA

* Pulsed-Power On-Wafer unless otherwise noted

Export Information
ECCN: 5A991.g
HTS (Schedule B) code: 8542.33.0000

Phone: (310) 814-5000 • Fax: (310) 812-7011 • E-mail: as-mps.sales@ngc.com

OVERVIEW

Power Amplifiers

Part	Description	Frequency (GHz)	Gain (dB)	P1dB (dBm)	PSat (dBm)	Availability
APH667	GaAs HEMT High Power Amplifier	81 - 86	17	TBD	25.5	Stock
APH668	GaAs HEMT High Power Amplifier	71 - 76	19	TBD	28	Stock
APH669	GaAs HEMT Medium Power Amplifier	81 - 86	16	20	23.5	Stock
APH670	GaAs HEMT Medium Power Amplifier	71 - 76	21	TBD	25	Stock

Before handling, assembling or testing our GaAs MMICs please review our "GaAs IC Die Handling, Assembly and Testing Techniques" application note

Power Amplifiers

Part	Description	Frequency (GHz)	Gain (dB)	P1dB (dBm)	Psat(dBm)	Availability
APH682	HEMT High Power Amplifier	92 - 96	7.5	22	25	Stock
APH684	HEMT High Power Amplifier	93 - 95	10	21	23	Stock
APH631	HEMT Power Amplifier	92 - 96	23	15	18	Stock
APH635	HEMT Power Amplifier	92 - 95	17	20	22	Stock

GaN Power Amplifiers Products

Part	Description	Frequency (GHz)	Gain (dB)	P1dB (dBm)	Psat (dBm)	Form	Availability
APN243	GaN HEMT Power Amplifier	23-28	20	38	40.5	Die	Stock
APN244	GaN HEMT Power Amplifier	23-28	21	37	39	Die	Stock
APN228	GaN HEMT Power Amplifier	27-32	19.5	39	41.2	Die	Stock
APN229	GaN HEMT Power Amplifier	27-32	20	17	39	Die	Stock
APN248	GaN HEMT Power Amplifier	27-31	17.5	42	44	Die	Stock
APN292	GaN HEMT Power Amplifier	27-31	20	42	42	Die	Stock
APN311	GaN HEMT Power Amplifier	27-31	20	43	45	Die	Stock
APN173	GaN HEMT Power Amplifier	34-36	19.5	TBD	37.5	Die	Stock
APN236	GaN HEMT Power Amplifier	34.5-35.5	16	38	40	Die	Stock
APN167	GaN HEMT Power Amplifier	43-46	20	35.5	38.5	Die	Stock
APN318	GaN HEMT Power/Driver Amplifier	47.2-51.4	15	-	40	Die	Pre-Production
APN319	GaN HEMT Power/Driver Amplifier	47.2-51.4	16	-	37	Die	Pre-Production

Part	Description	Frequency (GHz)	Gain (dB)	Output Power (dBm) P1dB
APN267	GaN HEMT Distributed Amplifier	2 to 18	10	35
APN270	GaN HEMT Power Amplifier	9 to 13.2	13	39
APN252	GaN HEMT Power Amplifier	10 to 14	25.5	34
APN250	GaN HEMT Driver Amplifier	10 to 14	13	39
APN226	GaN HEMT Power Amplifier	13 to 16	20	36
APN232	GaN HEMT Power Amplifier	13.5 to 15.5	13	38.5
APN237	GaN HEMT Dual Channel Power Amplifier	13.5 to 15.5	12.5	40.5
APN293	GaN HEMT Power Amplifier	16 to 20.5	10	36.5

[Website Links]
[YesWeGaN.com]
[https://www.northropgrumman.com/who-we-are/microelectronics-products/]

NORTHROP GRUMMAN

NGMC Silicon Technology – Baltimore

Technology	Status	Supply Voltage (V) Digital/Analog	Applications	Description	PDK
L-Band	Production	NA/50	Power transistors for pulsed radar/communications	Silicon NPN Microwave Power	Yes
S-Band	Production	NA/45	100 krads	Power transistors for pulsed radar/communications	Yes
CCD	Production	10/12	Visible image sensor	Indium Tin Oxide CCDs with 4µm CMOS 8V CCD Input Drive	Yes
PCBLVRH	Production	10/10	Smart power control (regulators, fault isolators)	Rad Hard 10V BiCMOS No PNP transistors	Yes
PCBMVRH	Production	15/15	Smart power control (regulators, fault isolators)	Rad Hard 15V BiCMOS No PNP transistors	Yes
PCB60	Production	15/60	Regulators for GaN devices	60V BiCMOS	Yes
PCB40RH	Pre-Production	15/40	Analog multiplexers, analog switches	100K Rad Hard 40V CMOS and Trench Isolation	Yes
CMS8	Production	5/5	SONOS FPGAs, CMOS ASICs, 1M EEPROM	Rad Hard 0.8µm CMOS with Nonvolatile Memory	Yes
CMS5	Production	3.3/5	CMOS ASICs	Rad Hard 0.5µm CMOS	Yes

NGMC Compound Technology – Baltimore

Technology	Status	Operating Voltage (V)	Applications	Description	PDK
SiC	Production	100	Power transistors for pulsed radar/communications	Discrete Silicon Carbide Power Transistors	Yes
GaAs HBT	Production	8	Upconverter, Downconverter, LO	Low phase noise HBT	Yes
SLCFET 3S	Production	-14	Switches, Switch Couplers, Switch Matrices, Reconfigurable Filters	Low-Loss, High Linearity RF Switch, RWOH available	Yes
SLCFET 3HP	Production	-20	Switches, Switch Couplers, Switch Matrices, Reconfigurable Filters	High Power, Low-Loss RF Switch, RWOH available	Yes
SLCFET Diode	Development	-14	Level Shifters for Receiver Protector, Limiters	Diode Integrated with SLCFET Switch	Yes
SLCFET Amplifier	Development	2.5 - 15	Power Amplifiers, LNAs, T/R MMICs	VHF - Ka band Superlattice Amplifier	Yes

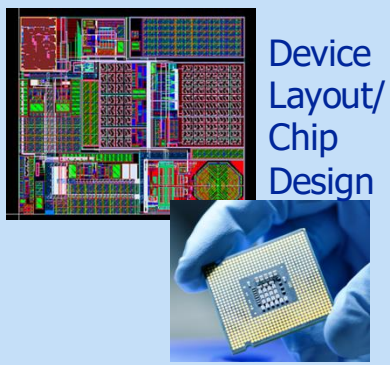
NGMC µ-Line for Wafer Post-Processing

Apopka µ-Line

Circuit Design → Wafer Fabrication → Wafer Bumping → Wafer Level Probe → Wafer Dicing → Board Assembly

IC Design

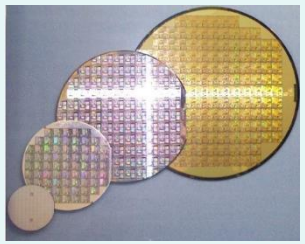
NG Design
Or
External Design
Services



Device
Layout/
Chip
Design

Wafer Fab

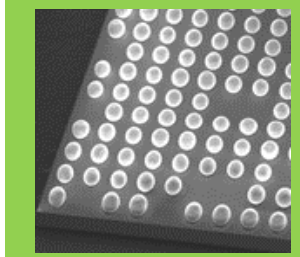
NG Wafers
Or
Silicon and
Compound
Semiconductor
External Wafers



Multiple Wafer
Sizes

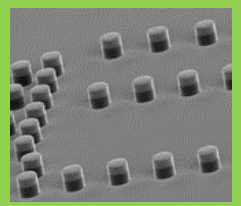
Wafer Bumping

Solder Sphere Drop
Or
Cu Pillars



Sphere
Drop

Cu
Pillars



Wafer
Probe

Whole wafer
probing

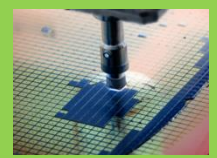
Thin/Dice/
Mark

Mechanical
Dicing
Die Laser
Marking

Die Level
Traceability

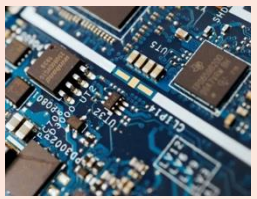
Die Pick

Die Sort
Waffle Pack
Or
Tape and
Reel



Board
Insertion

NG
Or
External
Service



NGMS Apopka µ-Line

Solder Sphere Drop Specifications

NORTHROP GRUMMAN

Parameter	300 µm Eutectic	200 µm Eutectic	200 µm High Lead	175 µm High Lead	80 µm Pb Free
Solder Alloy	Sn63Pb37	Sn63Pb37	Pb90Sn10	Pb90Sn10	SAC305
Passivation Thickness	5 µm	5 µm	5 µm	4 µm	5 µm
Polyimide Opening	180 µm	110 µm	110 µm	95 µm	61 µm
UBM Diameter	280 µm	180 µm	180 µm	146 µm	81 µm
UBM Thickness	5 µm	5 µm	5 µm	5 µm	5 µm
Average Height	235 µm	160 µm	160 µm	145 µm	60 µm
Average Diameter	320 µm	205 µm	205 µm	180 µm	85 µm
Shear	>283 gf	>90 gf	>90 gf	>60 gf	>8 gf
Recommended Pitch	500 µm	375 µm	375 µm	300 µm	150 µm
Wafer Size Capability	6”, 8” & 12”	6”, 8” & 12”	6”, 8” & 12”	6”, 8” & 12”	6”, 8” & 12”
Wafer Size/Alloy Production Ready	8”	8”	8”	8”	8”

NGMS Apopka µ-Line

Solder Sphere Drop Specifications

Wafer Size	Solder Sphere Drop	Cu Pillar	Plated Bump
100 mm	N/A	Development	Capability
150 mm	Capability	Capability	Capability
200 mm	Production	Capability	Capability
300 mm	Development	Capability	Capability

Alloy	Solder Sphere Drop	Cu Pillar	Plated Bump
Eutectic Sn63/Pb37	Production	Development	Development
Hi Lead Pb90/10	Production	Capability	Capability
SAC305	Capability	N/A	N/A
SnAg	Capability	Capability	Capability

Solder Sphere Size	Solder Sphere Drop
80 µm	Production
100 µm	Production
175 µm	Production
200 µm	Production
300 µm	Production

Microelectronics Products & Services (MPS)

NGMC External Sales Operating Unit

- MPS is NGMC's storefront for external access to microelectronics and microelectronic-based products
- Product portfolio includes ASIC sales, MMIC sales, foundry services, design and test services, wafer bumping, IC packaging and RF units
- Leverages NGMC microelectronics foundry technologies utilized in NGC space, airborne and ground products
- MPS business operates under fixed price contracts, commercial terms
  - Other Contract approaches are available for development & maturation
- All NGMC Sites are AS9100 & DMEA Accreditation of Trust

Defense Industrial Base

Provide discrimination to national asset systems

Commercial Market

Provide cost effective, high performing solutions

NGMC's Offering

- In 2024, Northrop Grumman has opened access to its Microelectronics capabilities and capacity to both the defense industrial base and commercial. To support this thrust, NG has re-organized our Microelectronics Sites, staff & capabilities into the Northrop Grumman Microelectronic Center (NGMC).
- NG's intention is to continue to address Microelectronics gaps which the domestic commercial microelectronic industry hasn't
- Value to you is a Microelectronics partner who understand performance and quality impact to USG systems along with the criticality of speed
- We have systems & controls in place to protect your IP and proprietary information
- Next Steps: Provide engagement opportunities with your Product Architects and Chief Engineers