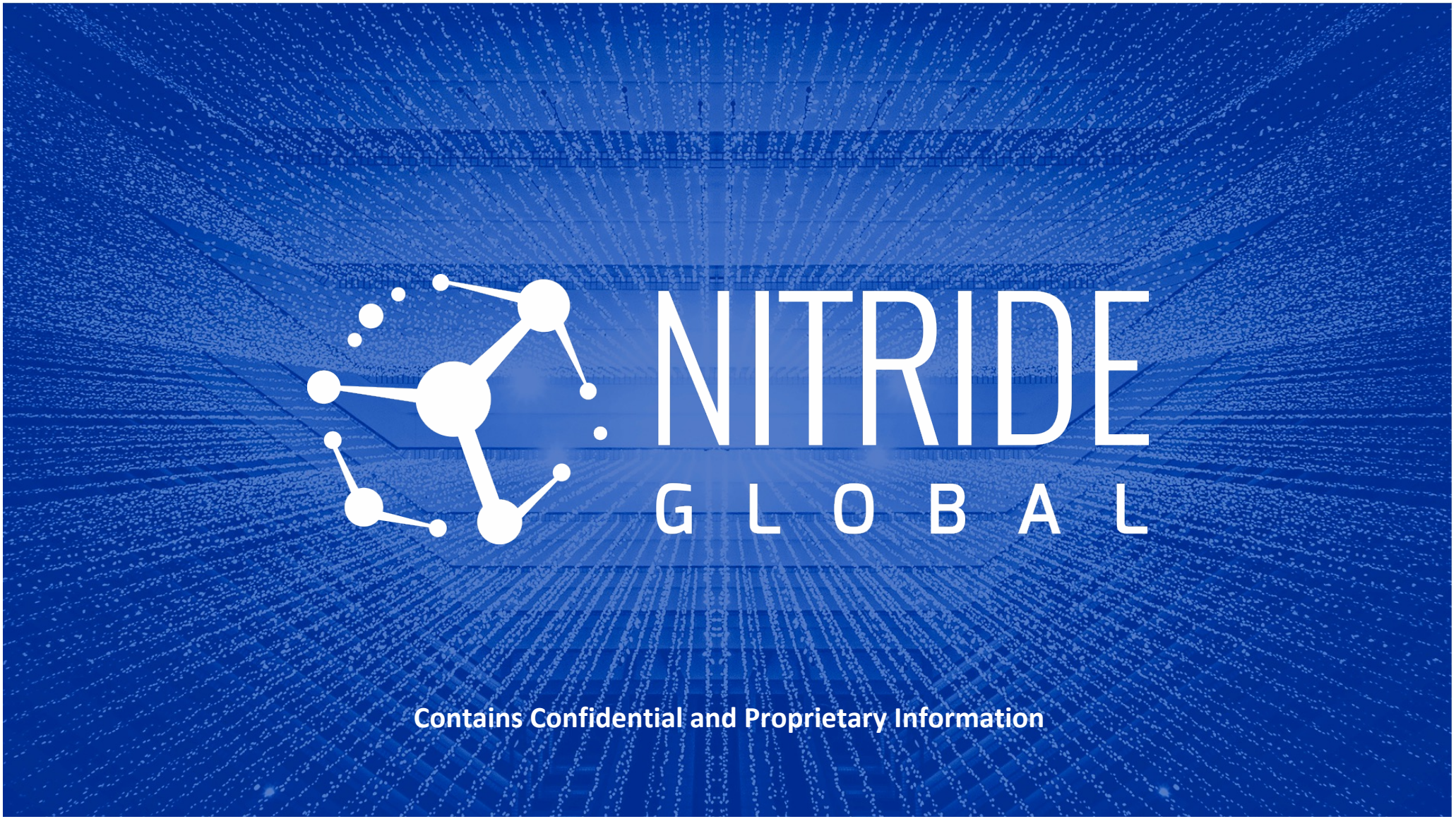
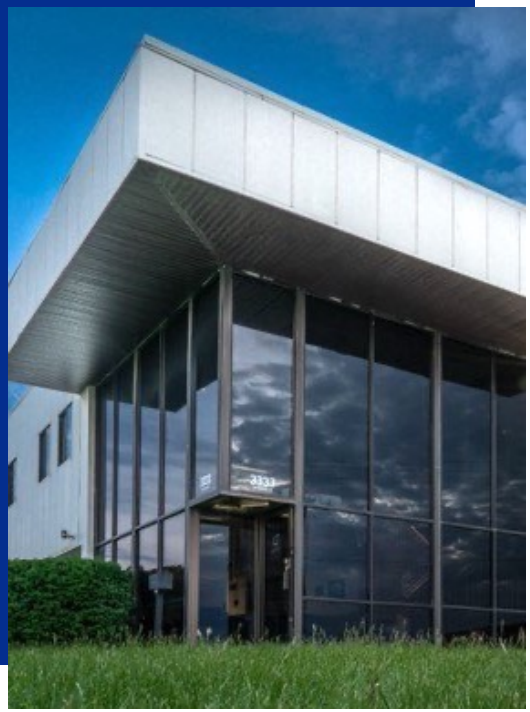
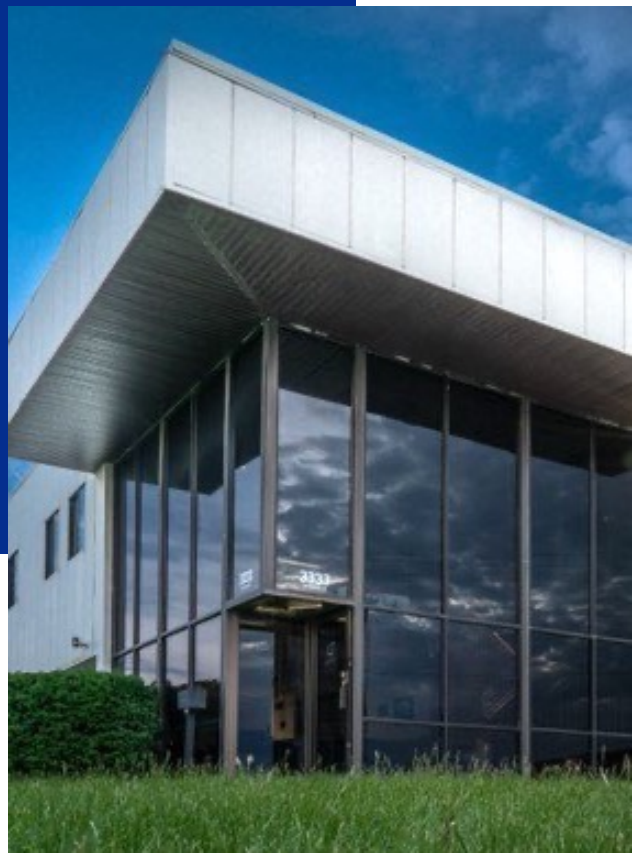

NITRIDE
GLOBAL
Contains Confidential and Proprietary Information



HQ: Wichita, Kansas

Nitride Global:
Executive Summary

- Advanced materials development & manufacturing company, with **8 patents & 2 pending.**
- The **ONLY** remaining North American owned company, and **one of only four companies globally** with this expertise.
- The material of focus, **Aluminum Nitride,** is now the top choice for next generation semiconductors in areas such AI Chips, EV, aerospace, & weapons.
- Existing revenue **($1M)** and profitability in AlN crystal growth product, with **3X growth** expected in **next 12 months**. Creating the **ONLY fully domestic supply** (raw to wafer) for an ultrawide bandgap material.
- **AlON Coating** product is a revolutionary thermal management solutions that can **double semiconductor life span and improve reliability by as much as 6X.**

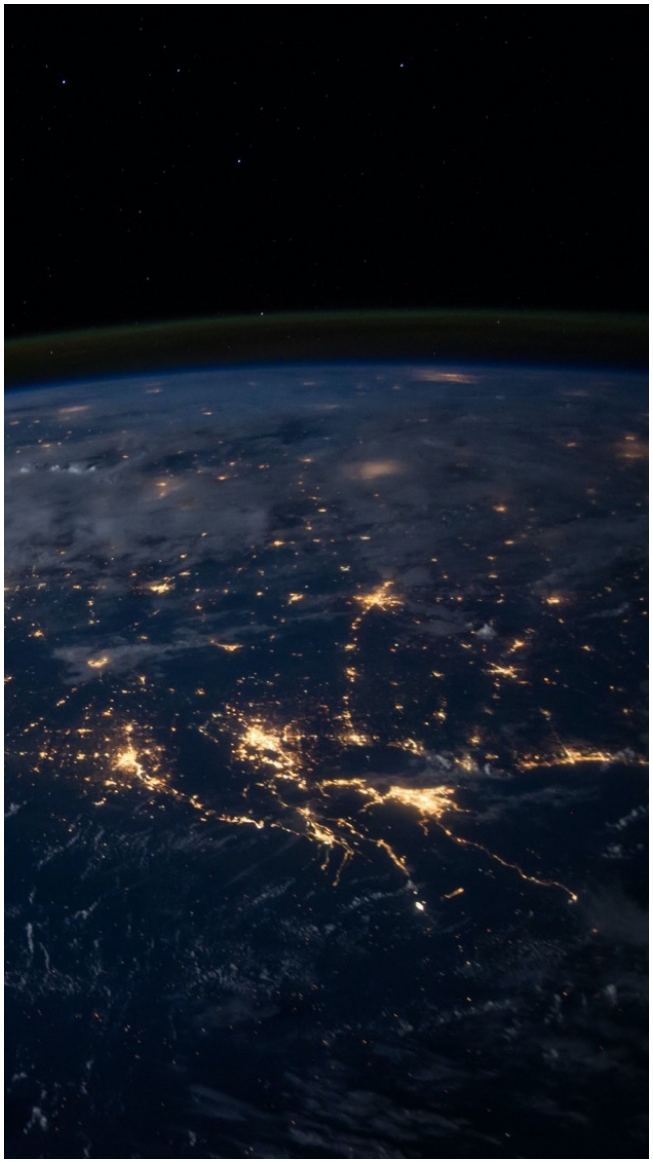


HQ: Wichita, Kansas

Who We Are
Nitride Global

Leading global supplier of high purity Aluminum Nitride (AIN) and Aluminum Oxynitride (AION) materials for advanced electronics, semiconductors, and optical devices.

- We manufacture the highest purity and highest value polycrystalline AIN on the market.
- Our new AION thermal management product is transformative for the microelectronics industry, with global patents on materials, global exclusivity to manufacturing technology.



Nitride Global

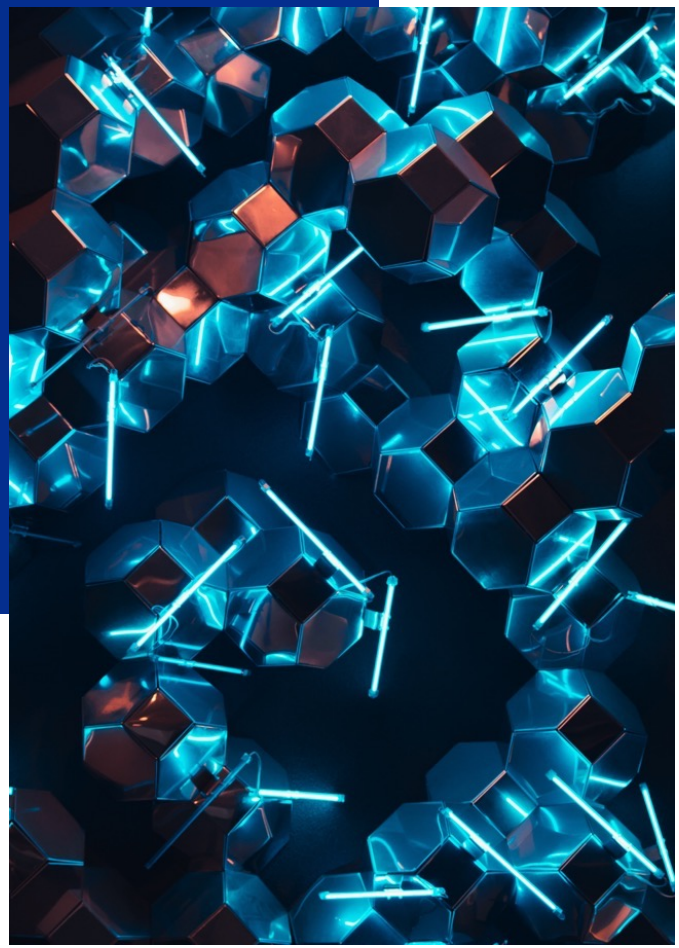
Enabling a New Generation of Semiconductors & Microelectronics

- Current semiconductor materials are reaching their performance limits in switching efficiency, thermal conductivity & performance, and electrical isolation.
- All current semiconductor material have dependencies on foreign controlled raw material.
- Current semiconductor packaging solutions have severe limitations in thermal resistance, size, and reliability in high power, high frequency, and optical applications.

Our innovations are addressing these challenges

Aluminum Nitride

Aluminum Nitride devices will revolutionize the electronics industry for high-powered, high-frequency, high-temperature devices and semiconductor packages.



- **Low thermal resistance**
- **Excellent electrical isolation**
- **High thermal stability over 1000C allows use in high-temp environments**
- **High chemical resistance allows use in corrosive environments**
- **Extreme resistance to radiation is suitable for space applications**

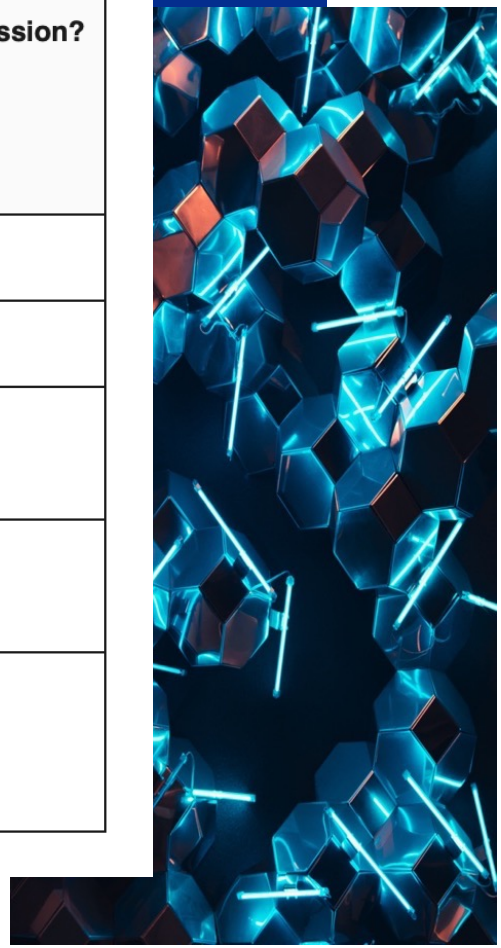
Property	AIN	SiC	GaN
Thermal Conductivity	300 W/(m.K)	52 W/(m.K)	180 W/(m.K)
Breakdown Voltage	1.7 kV	600 V - 5 kV	600 V
Operating Temperature	Stable up to 2200°C	210°C	400°C
Bandgap Energy	6 eV	3.3 eV	3.4 eV

Aluminum Nitrides
Advantages

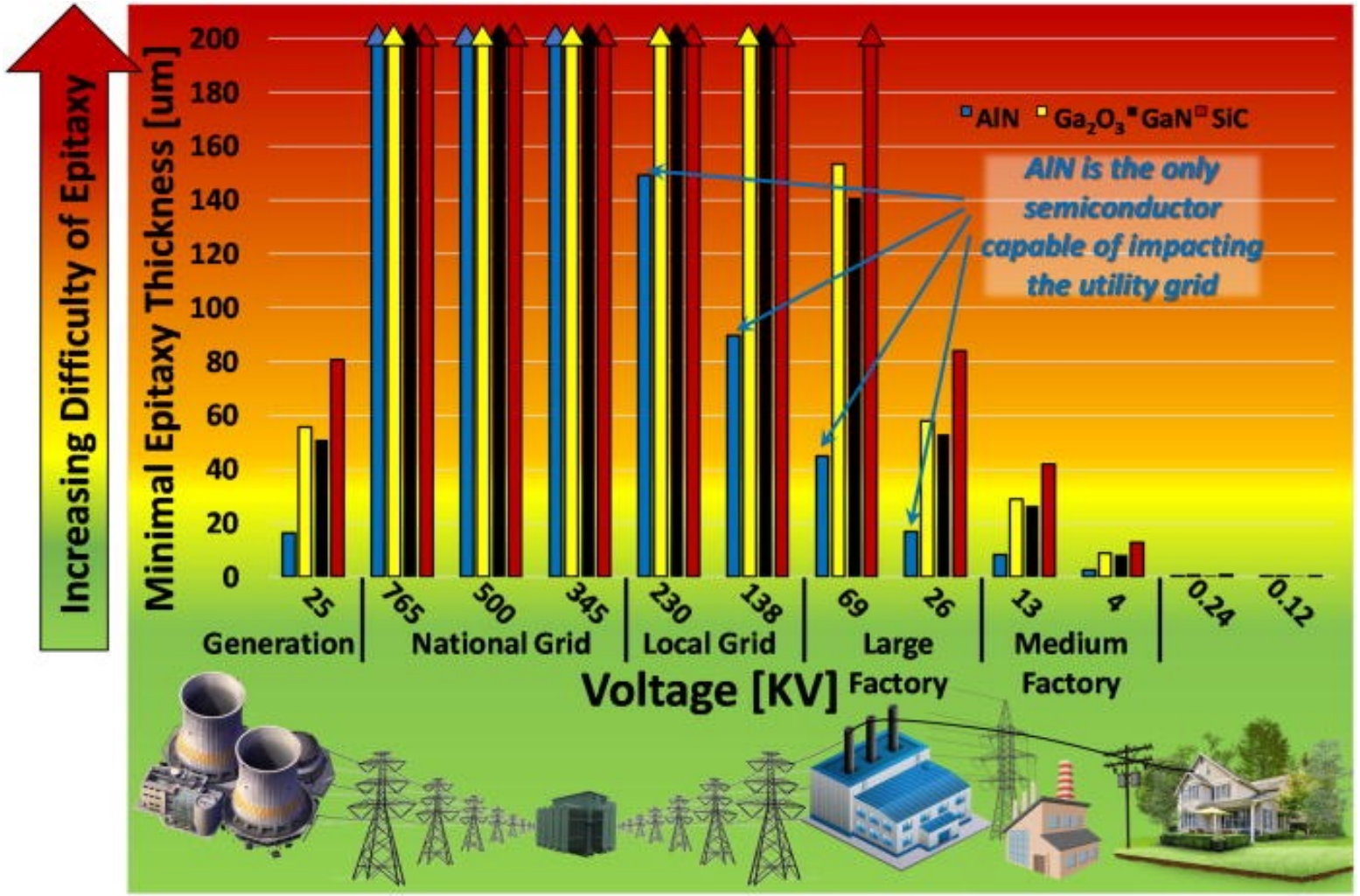
- 10,000x less transmission loss than silicon. **LEARN MORE**
- 2x the performance of current material (Gallium Nitride) for electronics and RF. **LEARN MORE**
- In Europe, est. 3 terra watt hours of power is lost in conversion for electronic devices. **LEARN MORE**
- Power loss expected to be only 5% of Silicon, 35% of Silicon Carbide, and 50% of GaN. **LEARN MORE**

Prospectives for AlN electronics and optoelectronics

Material	E_G (eV)	V_{sat} (10^7 cm/s)	E_{crit} at 10^{16} cm^{-3} (MV)	Thermal conductivity (W/m K)	Baliga FOM (10^6 $V^2/\Omega cm^2$)	Johnson FOM (10^{12} V/S)	V_{Break} at 10 mW cm^2 (V)	Substrate size (mm)	N-type/P-type?	Light emission?
Si	1.12	1.0	0.3	145	8.8	0.48	100	400	Yes/Yes	No
SiC	3.26	**1.9**	3.1	**490**	6270	9.4	3000	~150	Yes/Yes	No
GaN	3.45	1.4	4.9	253	27 900	11.0	5000	~100	Yes/Yes	**Yes**
β-Ga_2O_3	4.8	1.1	10.3	27	36 300	18.0	6000	~100	Yes/No	No
AlN (Parameter rank)	**6.1 (#1)**	1.3 (#3)	**15.4 (#1)**	319 (#2)	**336 000 (#1)**	**31.9 (#1)**	**20 000 (#2)**	~100	**Yes/Yes Lately**	**Yes**



Aluminum Nitride Devices in Power Grid



Aluminum Nitride
Defense Applications

Miniaturization

- Heads-up displays and wearables.
- 3x temp. resistance for in-engine sensors for hypersonic & supersonic use cases.
- Over 2x power density for high-power lasers.

Communications

- Over 2x bandgap performance of the latest airborne radar packages.
- 50% higher energy efficiency for low-power satellite components.
- Radiation resistant for space use and GenIV nuclear reactors.
- Long-range active listening devices.

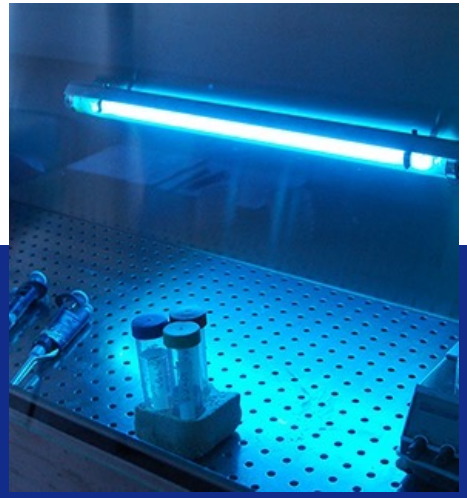
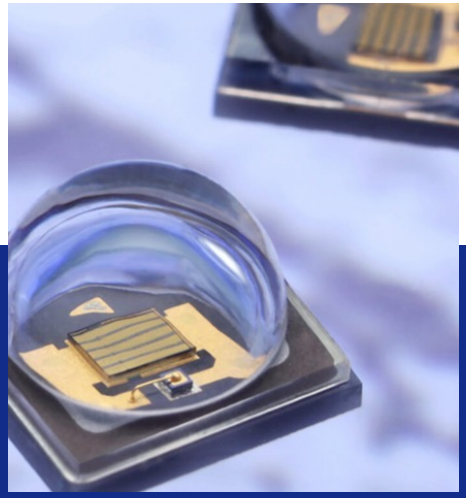
RF & Hypersonic Vehicles

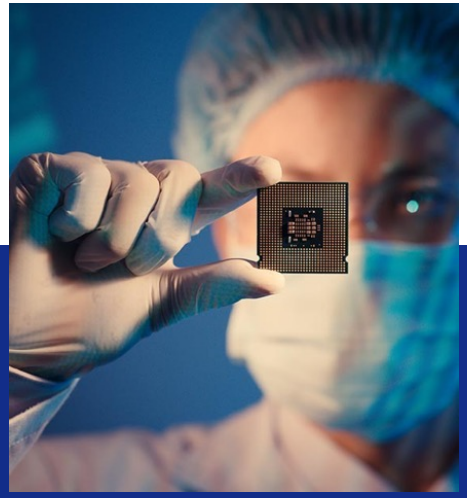
- Can enables ultra-high frequency components not feasible today.
- 5x power density compared to state-of-the-art.
- 2x better temperature stability compared to state-of-the-art.

Nitride Global Expertise

Polycrystalline Aluminum Nitride: High Power UV-C (Germicidal UV) LED and Semiconductors

Aluminum Oxynitride Coating: Thermal management for high power/high-frequency devices

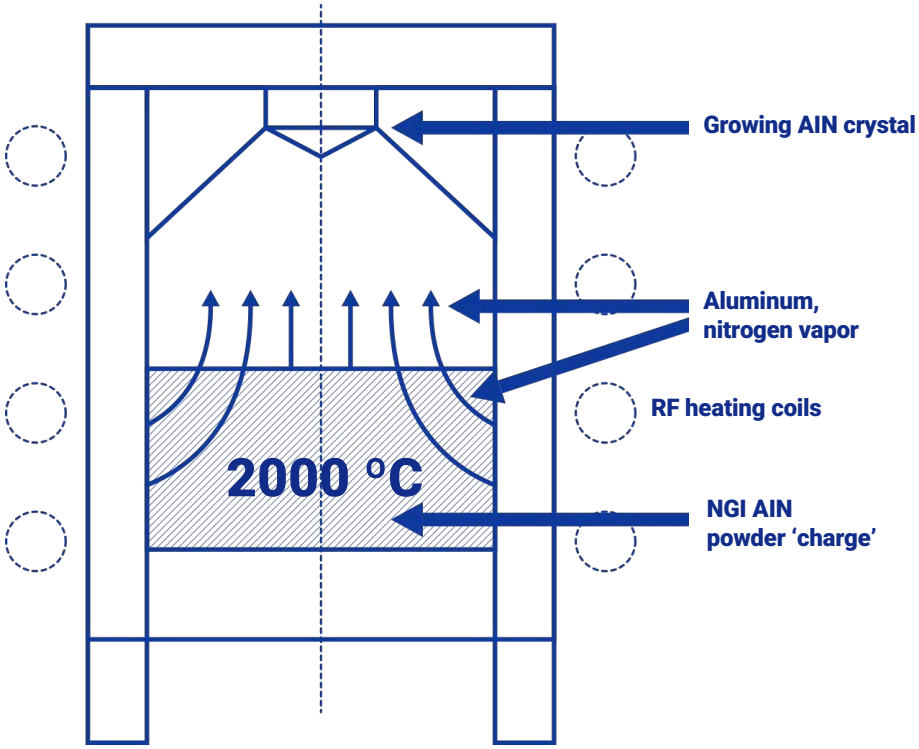



Polycrystalline
Aluminum Nitride

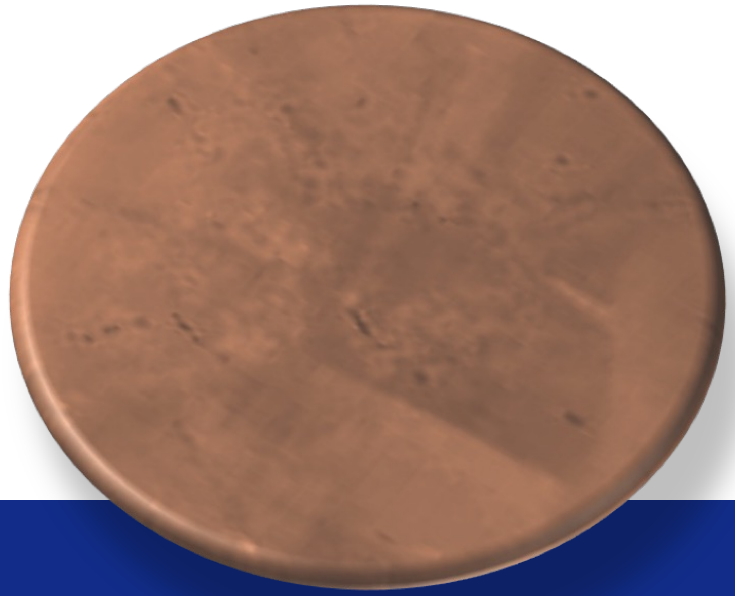
PVT Growth of
AlN Crystals

Highly proprietary process allows for high purity, fully dense material yielding much higher efficiency than alternative methods

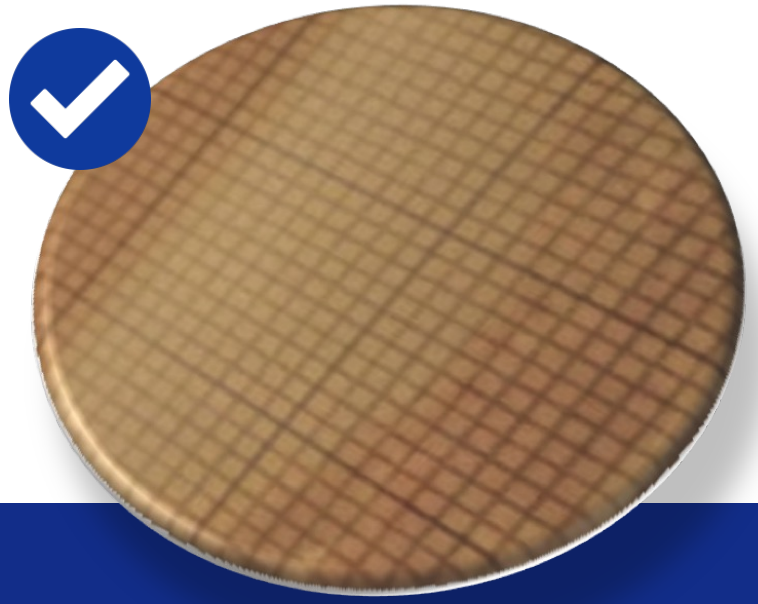
- **Purity: < 10^19 total impurities [C,O,Si,H]**
- **Density: > 99%**
- **Downstream Efficiency: 2x increase in production**



NGI Poly Drives
Improved Quality



Unstable growth due to outgassing
increases defects, reducing yield.



NGI Poly provides stable growth,
low defectivity, improved product yield.

Markets & Opportunities

Creating a Safe Living Environment with UVC LEDs

- New Air and Surface Purification with Light—chemical and ozone-free.
- Keep surfaces free of pathogens without harsh chemical disinfectants.
- Kills 99.9% of Coronavirus

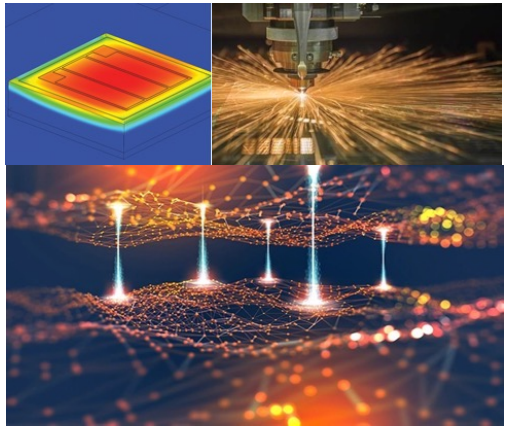
NGI's poly AIN enables the creation of higher output UV-C LEDs that are effective at killing bacteria, molds, and pathogens.

Aluminum Oxynitride Coating

Transforming Advanced Electronics

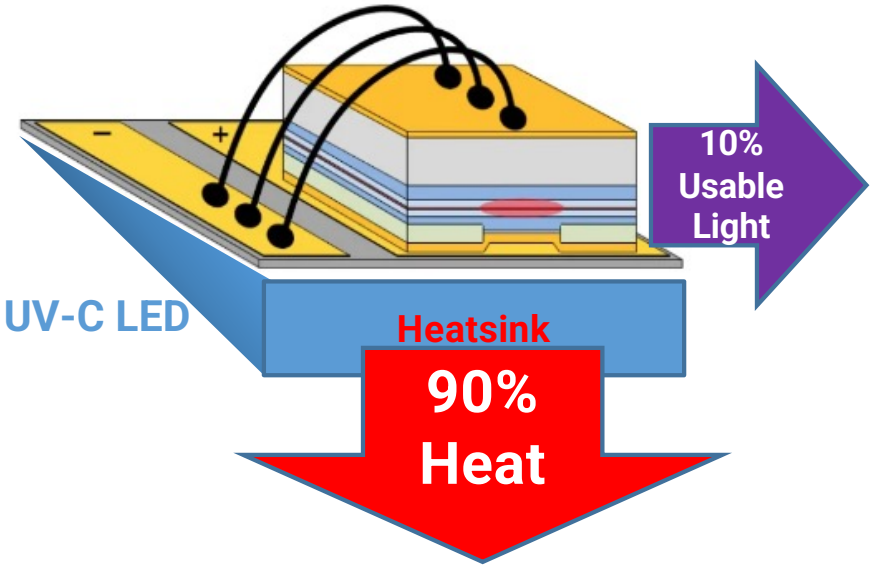
WHAT IF YOU COULD

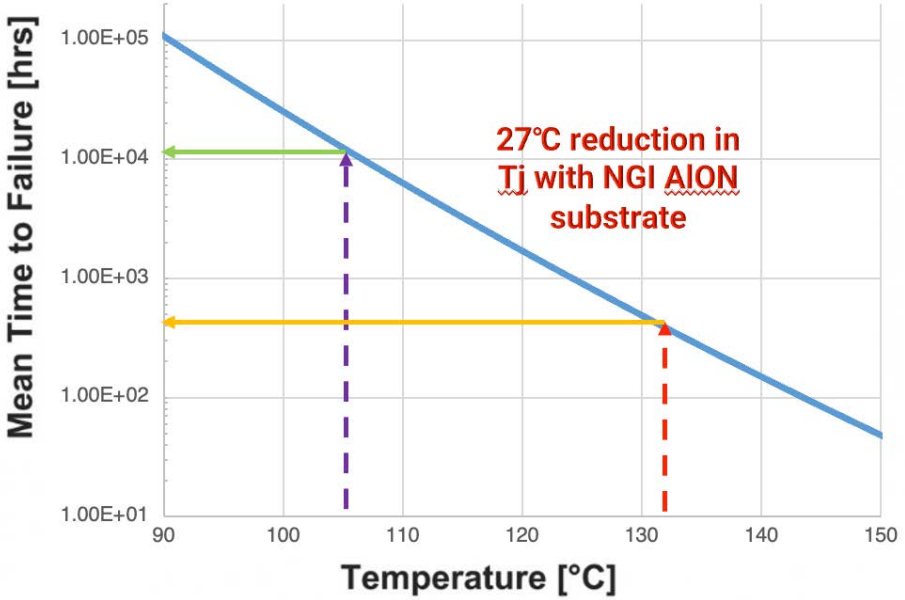
- Improve thermal efficiency of microelectronics by 30%?
  By replacing the unnecessary packaging layers
- Improve the efficiency of an EV-inverter by 25%?
  By minimizing the heat-soaked induced electrical losses
- Extend the life of a laser diode by 10,000 hours?
  By lower junction temperature and slowing thermal degradation
- Improve efficiency of a thermoelectric cooler by 50%?
  By reducing the thickness of the ceramic electrical isolation layer
- Extend the service duration of a semiconductor e-chuck by 100%?
  By increasing chemical etching resistance of the protective layer



We are Significantly Increasing Reliability and Efficiency of Microelectronics & Semiconductors

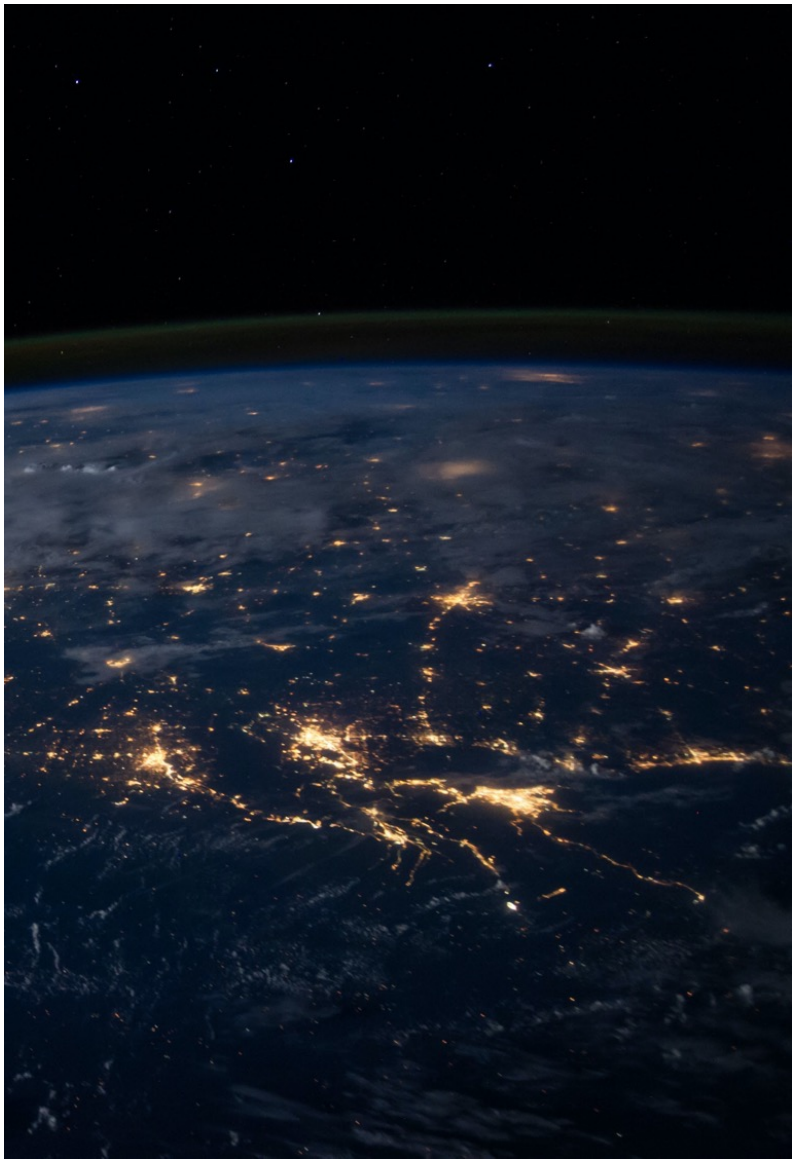
Heat generated as a result of thermal barriers reduces efficiency





And for every 10 °C the temperature is reduced the lifetime doubles.

Advanced packaging can increase device power and lifetime



Nitride Global
Aluminum Oxynitride Coating

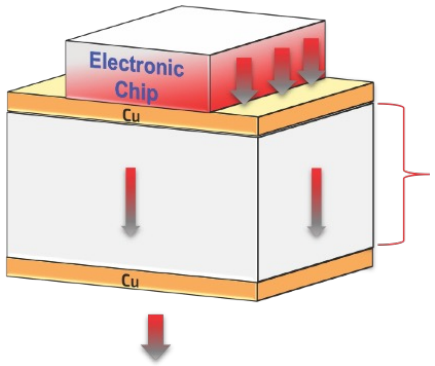
Enabling a New Generation of Electronics

- Enables device performance breakthrough by providing a new type of thermal management and protective coating solution to the market.

- Efficiency increase in data transmission systems, high-powered electronics, and portable devices leads to a significant reduction in energy usage and greenhouse gas emissions

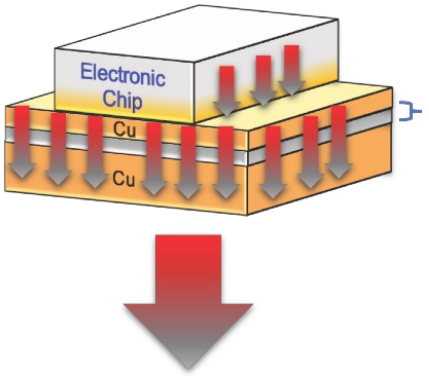
AION Coatings: Revolutionary Dielectric Thin Film

Step-Change Performance – Innovation of the AION to substrate Interface



Thick ceramic dielectric high thermal impedance

Limited thermal transport due to ceramic thickness



NGI Thin Dielectric

Enhanced heat transport

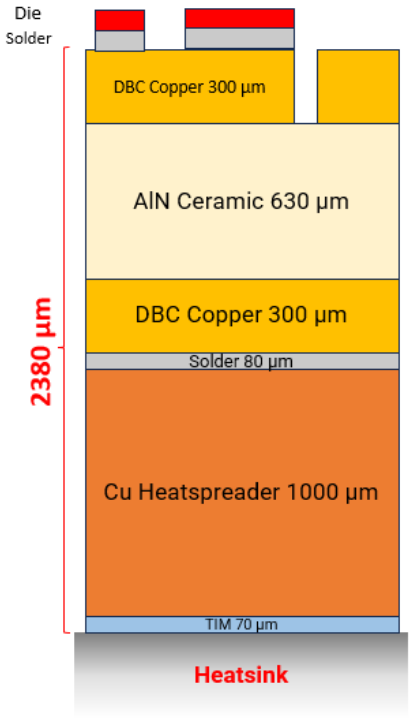
Material	Thickness	Thermal Resistance (K/W)*
NGI AION	**10**	**1.0**
AIN DBC	630	1.3
AIO DBC	320	4.1

**Normalized to AION equals 1: Assumes cross sectional area of 800 mm*

Aluminum Oxynitride in Devices

Revolutionary Thin Film Packaging for Power and RF Devices

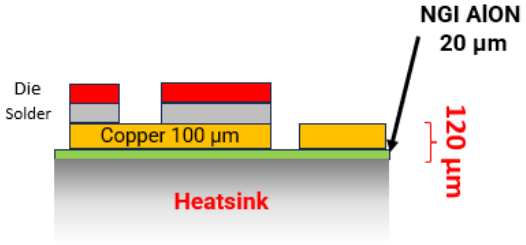
Current Industry Standard "Die on DBC"



NGI AlON Copper Package Characteristics	
Low temperature deposition	< 300 ℃
Excellent V_{BD}	up to 540 V/µm
High chemical etching resistance	7x > SiO_2 from NF_3
Thermal Conductivity	2 W/m-K – 30 W/m-K
Flexible but mechanically robust	210 Gpa
Very high reliability	> 1000 cycles @ -55℃ to 150℃
Suitable for high temp. applications	< 300 ℃

Moving Beyond Ceramic Substrates

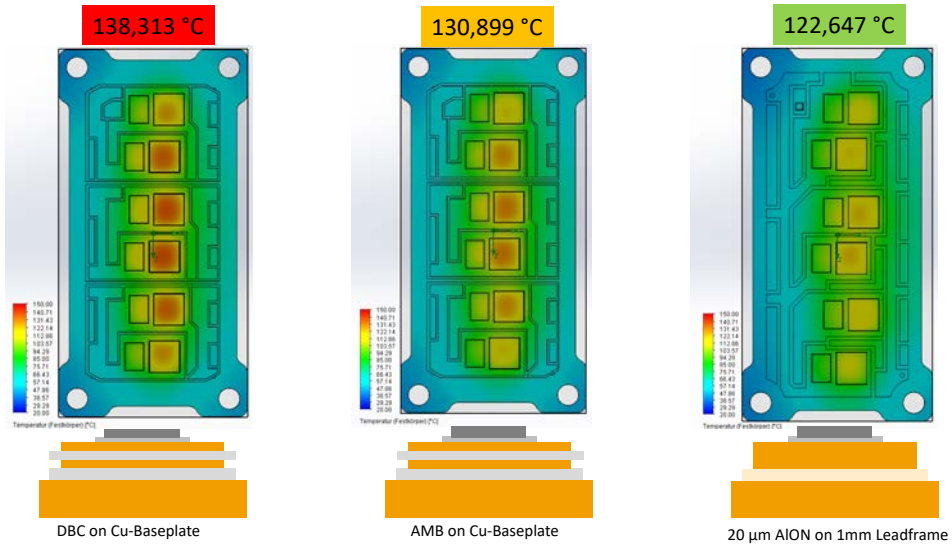
NGI AlON Concept "Die on Heatsink"



Semikron Danfoss EV Power Module IGBT Operating Temp Comparison

SEMIKRON DANFOSS

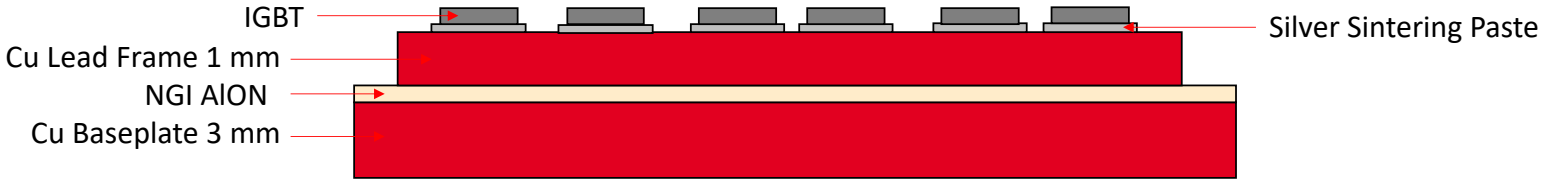
Fachhochschule Kiel
Hochschule für Angewandte Wissenschaften



Comparison between ceramic modules and 20 µm AlON with 0.1 mm Cu lead frame

Every 10°C reduction doubles lifespan

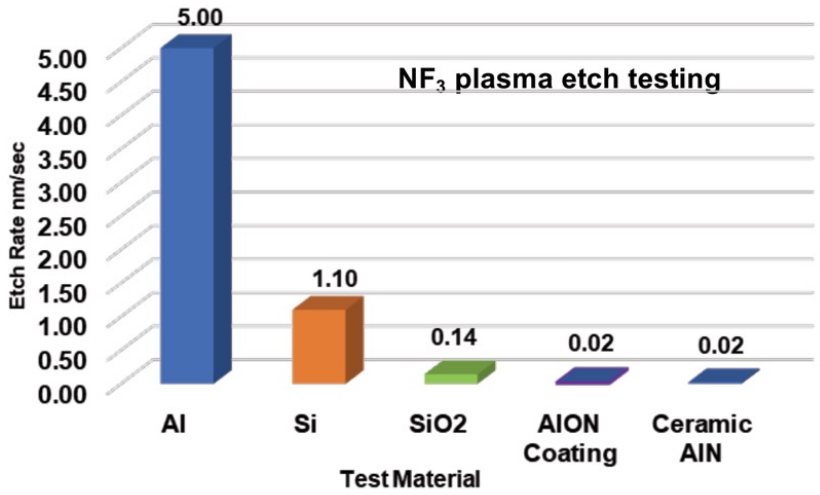
NGI AlON has been shown to have 6x higher reliability than DBC/ AMB



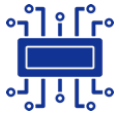
DoL-layout top view and sketch cross section

Extended Lifetime of
Semi Process Equipment

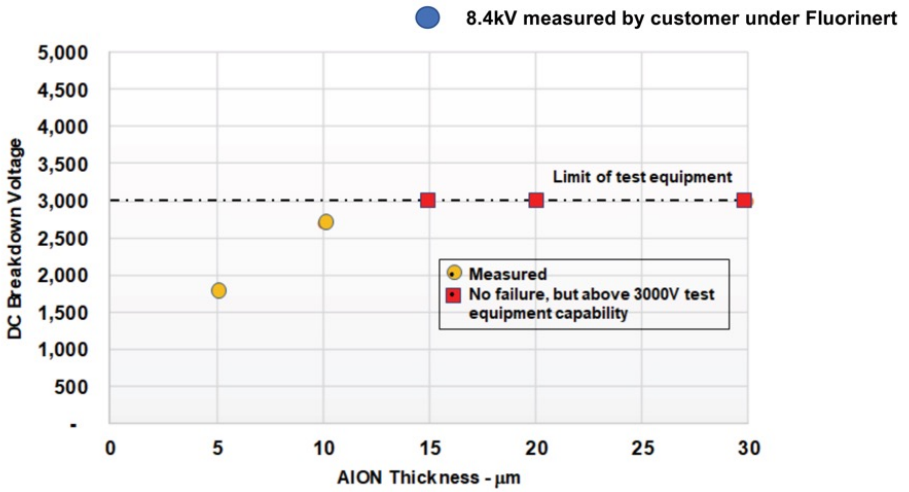
- AION coatings provide extended protection against NF cleaning plasmas
- **Provide up to 2x extended run life**
- Sheet resistivity can be tailored for Coulomb and J-R electrostatic chucks

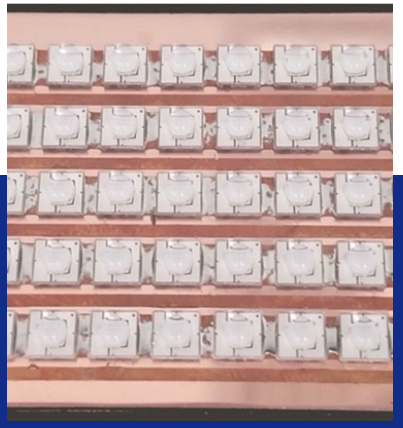


NGI AION Coatings Dual Use Applications

	 Power Electronics	 Laser Diodes	 Electronics Cooling	 Semiconductor Manufacturing	 Aerospace & Defense
Our Solutions	AION coatings for MOSFET & IGBT packages	AION coatings for diode packaging	AION coatings for Thermoelectric devices	AION protective coatings for electrostatic, vacuum wafer chunks.	AION Thermal, Insulating, and Protective Coating for high power, high temp, high frequency devices
Customer Applications	EV inverters and power electronics	Cutting, additive manufacturing, 3D sensing (LiDAR)	Telecom, low GHG refrigeration	Deposition, etch tools	Hypersonic Vehicles, Directed Energy, High Frequency/ Resolution Radar, Low Power Satellites
Value Proposition	Longer range, faster charging, lower heat	Faster cutting, better resolution & response time, longer life	80x faster cooling, lower power usage, cost	2X longer tool uptime	A new generation of devices and performance/ reliability metrics
Addressable Market, CAGR	> $0.2b, 15%	> $0.4b, 13%	> $0.6b, 8%	> $0.5b, 7%	> $1b, 8%

Customer/NGI Testing Results

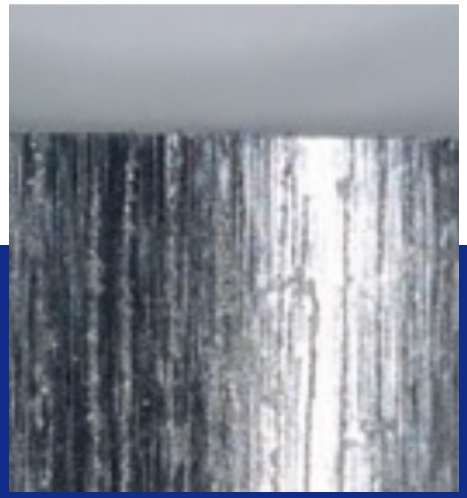




Customer/NGI Testing Results

- Knife test: PASS, Open/Short: PASS
- Solder bonding test: PASS
- Pull Strength Area A - 9.64 lbs, Area B - 7.14 lbs, Area C - 7 lbs, Area D - 7 lbs: PASS
- Breakdown test 500 V: PASS, > 10 MOhm: PASS
- No spalling, delamination from 180° u-bend test on Cu, s-bend test on Al



Strong Partners and Customers

Customer Engagements

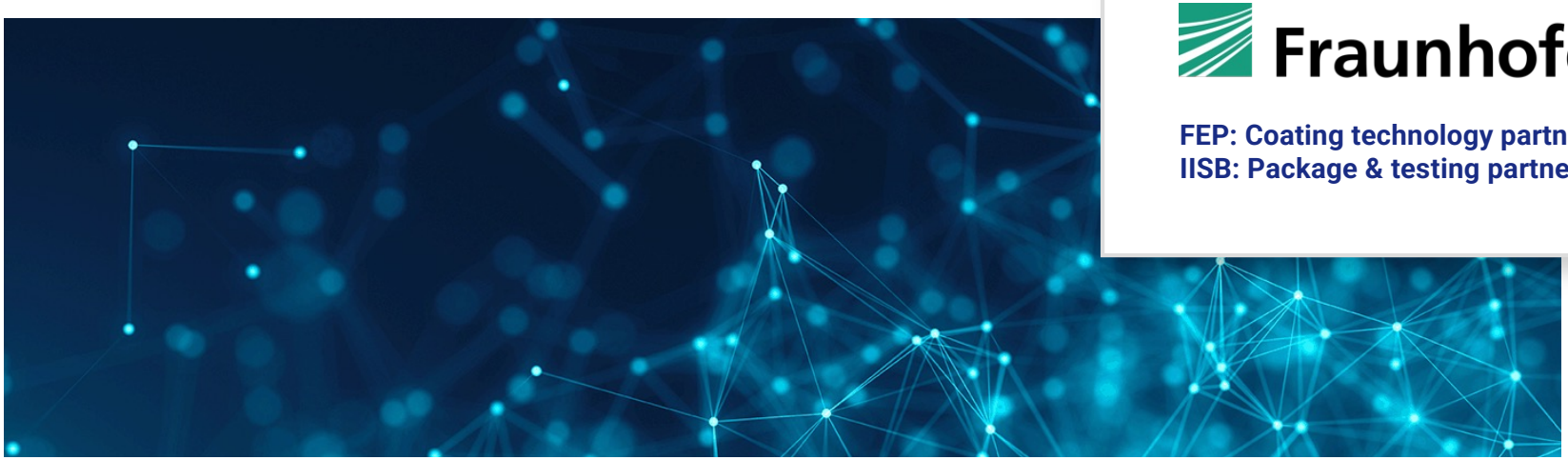
#1 Thermoelectric Cooler OEM

#1 Laser Diode OEM

#2 Power Electronics OEM

#2 Electronics Packaging OEM

#3 e-Check OEM



JSR Corporation

Funded coatings JDA
Co-marketing and manufacturing partner

Fraunhofer

FEP: Coating technology partner
IISB: Package & testing partner

About Nitride Global

Our Leadership Team

Mahyar Khosravi, P.Eng.

Chief Executive Officer

- 20+ years in global technology roles with organizations such as Cisco, Nortel, etc.
- Experienced VC/PE Investor
- Startup to growth scale experience

Matthew D. Healy, Ph.D.

Chief Strategy Officer

- 20+ years experience in Electronic Materials,: Product Management, Applications Engineering, and M&A
- Air Products, ATMI, Ferro Corporation, Kurt J. Lesker Company

Jason Schmitt, MS, MBA

VP, Research & Development

- 20+ years of experience in nitride crystal growth, reactor design
- Deep expertise in substrates and thin film coatings

Jeremy Jones, MS, MBA

VP, Business Development

- Vast experience in building global advanced materials businesses
- Motorola, Cabot Microelectronics, Koch Genesis

Advisors & Consultants

Duncan W. Brown Ph.D.

Consultant/ Advisor

- 20+ years of experience consulting with Japanese and American technology companies
- Founder of Pacific Tech Link American and Japanese tech companies
- One of the Founders of ATMI

Mark Kennard Ph.D.

Consultant

- 25+ years in the semiconductor industry with C-level and VP experience
- Author or co-author of 12 patents and more than 30 journal articles
- Lam Research, Soitec, AMAT, Svagos Technik

Haris Basit, MS

Advisor

- 30+ years in the semiconductor and electronics industries. Founder of multiple successful companies.
- Significant expertise in EDA, semiconductors, High-Frequency Trading software, crypto, and licensing IP.

Christian Winkler Ph.D.

Consultant

- Managing Director—Global BA
- Long experience in electronic device and electronic materials market for companies such as Rogers, KCC Corp., Nippon Steel, NGK Electronic Devices.


NITRIDE
GLOBAL