DIAMOND'S UNFINISHED REVOLUTION

Preparing for the next 100 years

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Lab-grown diamond is still in its opening chapters

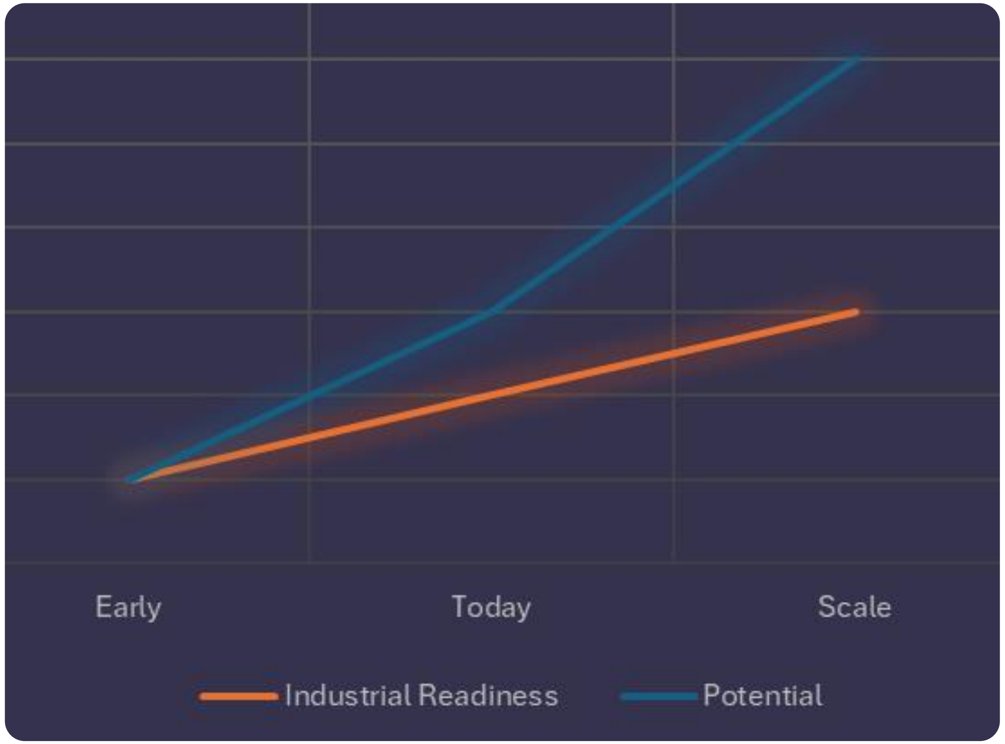
The first 70 years were about discovery and niche adoption.

The next century will be about greater scale, integration, and broader impact.

Diamond: "A 100 Year Material"

A phrase that captured diamond's promise - but not the pace of its adoption.

1. Lab-grown diamond has existed for decades, yet the field is still early relative to its potential.
2. Applications have been realized faster than the manufacturing capabilities to support them.
3. This mismatch continues to broaden - potential versus industrial readiness



Diamond’s advantage is not any one property — it is the combination

When thermal, electrical, optical, and environmental strengths align, new applications emerge.

Thermal

Highest thermal conductivity makes diamond relevant anywhere thermal bottlenecks limit performance.

Electrical

Ultra wide bandgap, high-field potential, and many other properties keep diamond at the forefront of power and RF device research.

Optical

A broad transmission window keeps diamond useful in demanding photonic and laser applications.

Environmental / Mechanical

Radiation hardness along with broad chemical, thermal, pressure, hardness, and acoustical tolerances open the most challenging applications.

Diamond’s application space is broad — and still expanding

Although it is rarely the first material considered.

When other materials reach their limits, new diamond applications emerge.

Quantum
- Sensors
- Networks
- Computing

Electronic
- Diodes
- Transistors
- Detectors

Mechanical
- Abrasives
- Cutting and grinding
- MEMS
- Acoustics

Thermal Management
- High-power laser diodes
- Semiconductor packaging
- Disk laser heat spreaders

Optical
- Laser windows
- Photonics
- Spectroscopy

Many of diamond's most important applications were not predicted

Adoption has been shaped by emerging system bottlenecks.

The priority is not perfect forecasting — it is building the capability to respond.

EUV lithography

Optical properties, beam quality, and reliability requirements created demand few would have forecast early on.

AI thermal management

As compute density rises, demanding thermal management requirements create a new pull for high-conductivity materials.

Quantum sensing

Magnetometers and other color-center applications are expanding diamond's role in precision sensing.

Diamond is not limited by its potential — it is limited by our ability to integrate, industrialize, and scale it

One challenge today is compatibility with modern semiconductor manufacturing.

Key enablers include 300 mm process compatibility, low-temperature bonding or deposition, and CMOS-last integration.

Develop

Leverage material properties
Advance new products
Create disruptive technologies

Integrate

Devices
Packages
Systems

Industrialize

Repeatable manufacturing
Consistent quality
Qualified supply chains

Scale

High volume production
Improving yield
Lowering costs
Larger sizes/diameter

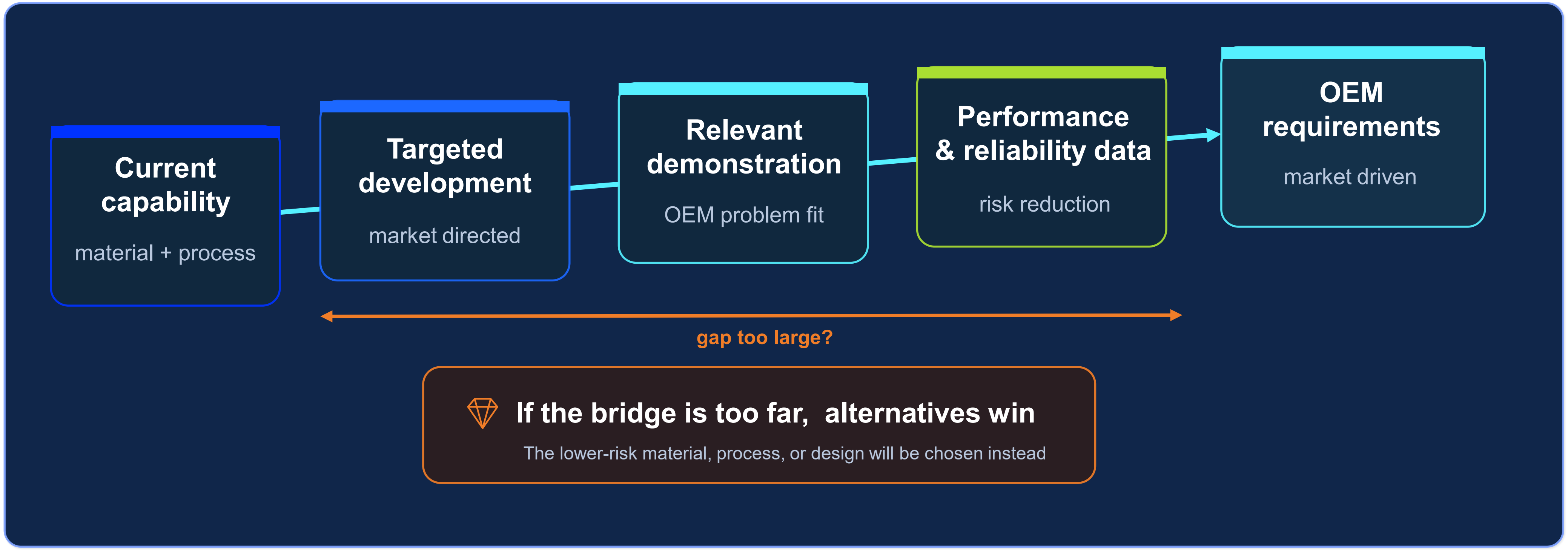
Progress is real — but broad adoption is still bottlenecked

Performance, manufacturing readiness, and market pull are not advancing together.

Diamond is not the limitation. Uneven readiness across the value chain is.

OEMs need credible stepping stones, not a leap of faith

Incremental advances close the gap between current diamond capabilities and OEM application requirements.



What the next decade must deliver

The path forward is a continual sequence of industrial milestones

Reaching scale will likely require fundamentally new manufacturing approaches

The next breakthroughs may still be hard to predict. The next industrial tasks are not.

1. **Bigger, higher quality material**
   Larger formats
   Engineered defects
   Consistent quality

2. **Advanced fabrication**
   Wafering
   Polishing
   Shaping

3. **Improved yields and cost**
   Lower energy inputs
   Repeatable processes
   Manufacturable design

4. **Integrated packaging**
   Heterogeneous integration
   Photonic circuits

5. **System wins**
   Bottleneck solved
   Performance targets met
   Makes economic sense

COHERENT

Materials alone do not create markets

Diamond markets emerge only when every stage of the chain is strong

Material

Repeatable growth
Required form factors
Qualified metrology

Device

Process flows
Performance
Yield

Subsystem

Packaging
Thermal design
Reliability

System

Integrated platform
Qualified products

Market impact

Solves a bottleneck
Provides customer value

A break anywhere in this chain can keep diamond technically impressive and commercially small.

Coherent is building a platform, not just a material offering

That platform spans growth, fabrication, polishing, coatings, and optical metrology - built on decades of process know-how.

MWCVD growth

Designed and built growth reactors. Developed processes to produce application specific PCD & SCD materials.

Laser processing

Translate as-grown material into usable form factors.

Surface finishing

Enable optical quality surfaces while controlling to exacting specifications.

Coatings & metrology

Coat and measure what matters with confidence.

Automation & productization

Deliver repeatable output.

Coherent began to coat diamond for CO_2 slab lasers in 1996. The bigger strategic move was building a platform to serve developing markets.

Government investment moves the ecosystem forward

The right programs accelerate transition, demand measurable progress, and help bridge the gap. Visible progress earns continued support.

Research pull

Advance concepts and de-risk early pathways.

DARPA

Pilot infrastructure

Build capabilities that can be transitioned into industry.

Microelectronics Commons

Demonstrators

Prove performance in needed systems.

Microelectronics Commons

Transition programs

Promote industrialization.

This site has a history of turning technical innovation into industrial reality

Diamond is the next chapter in that story.

KDKA era	Carnegie Institute	II-VI Inc.	Coherent
1920s	1950s	1970s	2000s

Broadcast innovation

The site lineage begins with early radio broadcast milestones. Highest power transmitters at the time for experimental and commercial development.

Nuclear research

435 MeV synchrocyclotron built by the Carnegie Institute resulted in foundational work on nuclear structure and meson particles.

Infrared materials

Developed optics to support the emerging CO_2 laser industry. From scientific capability to engineered materials and production know-how.

Diamond platform

Today's challenge is to do it again - move a remarkable material toward broad acceptance across many industries.

Today, we're positioning diamond for its next 100 years

Advancing the industry requires steady progress in diamond technology and systems integration.

Prove. Integrate. Scale.

That is how diamond moves from remarkable capability to foundational technology.

THANK YOU!

COHERENT CAPABILITIES (REDACTED)

Diamond Background

May 13th, 2026

CVD DIAMOND AT COHERENT

- **Polycrystal diamond sales since 2010**
  - CVD growth technology developed in-house
- **Single Crystal capability added in 2024**
  - IP Licensing Agreement / Tech Transfer with Element Six
- **All processing in Saxonburg, PA**
  - Growth (Poly and Single Crystal)
  - Fabrication (Laser Cutting, Polishing, Marking)
  - Coatings, QA, Metrology

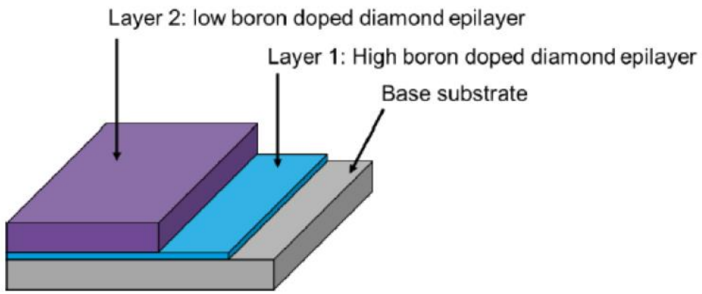
COHERENT DIAMOND PRODUCTS

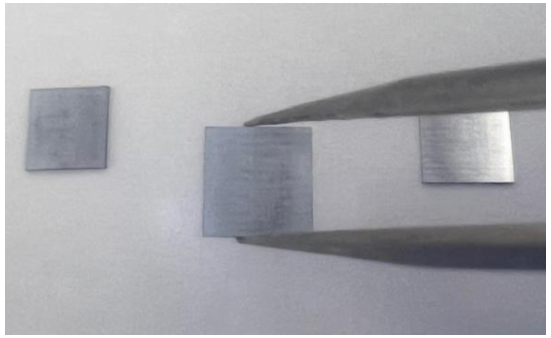
	Grade	Applications
Polycrystal	Optical	High power CO_2 laser windows, EUV
	Thermal (T-1500, T-2200)	Heat spreaders for electronics and lasers
	Detector	High-energy physics research
	Microwave	Fusion research, Directed energy
	Composites (CVD/Thermadite)	Cold plates, High Energy Laser Mirrors
Single Crystal	Optical	Hyperspectral
	Thermal	Heat spreaders, direct bondable
	Electronic + Boron Epi	Substrates, Power and RF devices
	Quantum (NV^- diamond)	Sensing, Networks, Computing

Polycrystal sizes to:

- 150mm+ diameter
- ~2.5mm thick

GOVERNMENT PROGRAMS

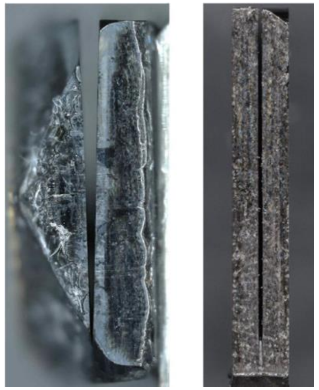


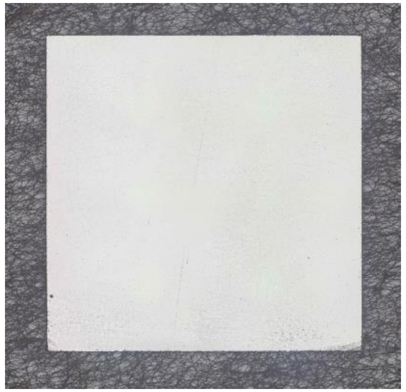


- **Microelectronics Commons**
  - Develop capability to produce **boron doped diamond epitaxy**
  - Deliver materials to GE Research
  - Submitted proposals for additional funding
    - Thermal Management
    - Quantum

- **DARPA Ultra-Wide Bandgap Semiconductors (UWBGS)**
  - Collaboration with The Applied Research Laboratory at Penn State, a UARC facility
  - Year 2 goal of delivering high quality 50mm SCD wafers, with optional year delivery of 100mm SCD wafers
  - Large-area mosaic single crystal diamond via innovative seed cloning enabled by water-jet laser technology

Conventional Water-Jet





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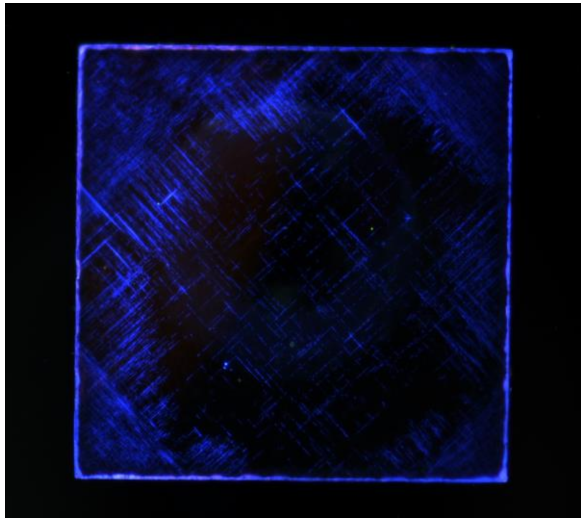
COHERENT CAPABILITIES

Electronic Diamond

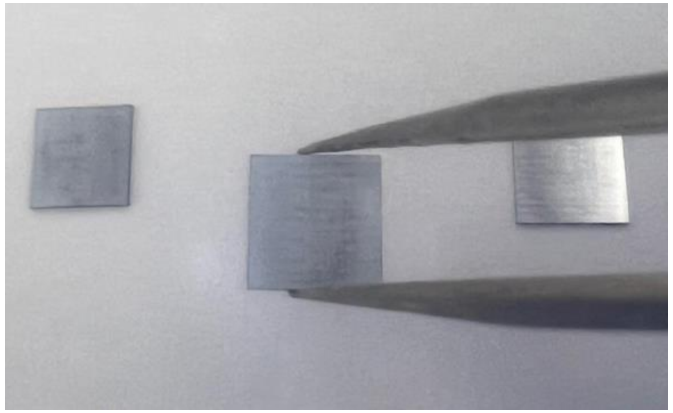
May 13th, 2026

SCD DIAMOND GROWTH FOR ELECTRONICS APPLICATIONS

- **Coherent is expanding its offering of materials for diamond electronics**
  - Bulk and epitaxial **undoped** diamond up to $7x7mm^2$
  - Epitaxial **boron doped** diamond growth (1E16-1E20 atoms/cm^{-3})
- **Dedicated reactor for boron doped diamond**
  - Coherent's first boron-doped SCD grown on-site in October 2025



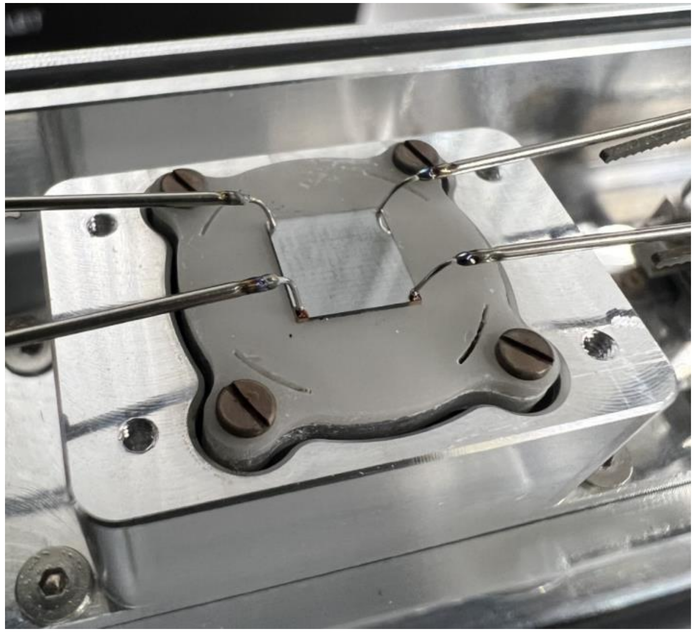
Electronic grade (undoped) SCD



Coherent-grown p-type SCD

ELECTRONIC DIAMOND MATERIALS CHARACTERIZATION CAPABILITIES

- **Hall Effect Measurement System**
  - LakeShore M91 FastHall Controller
  - Temperature control from RT to 1000ºC under vacuum
  - Contact metal deposition capabilities in house
- **De-Beers DiamondView Fluorescence Imager**
  - Detect ~ppt [Ns^0]



- **Panalytical Empyrean X-ray diffractometer**
  - Degree of offcut has an impact on boron incorporation
- **Optical microscope, SEM, AFM and Interferometers**
  - Surface morphology

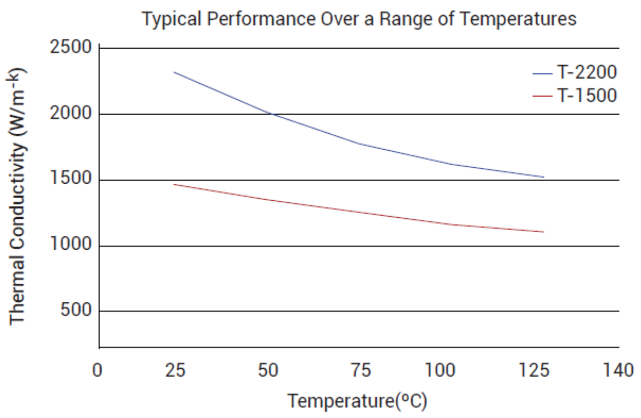
COHERENT CAPABILITIES

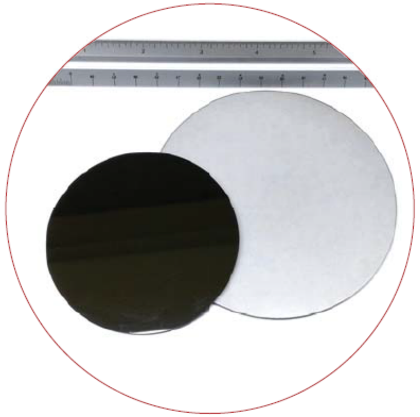
Polycrystalline & Quantum Diamond

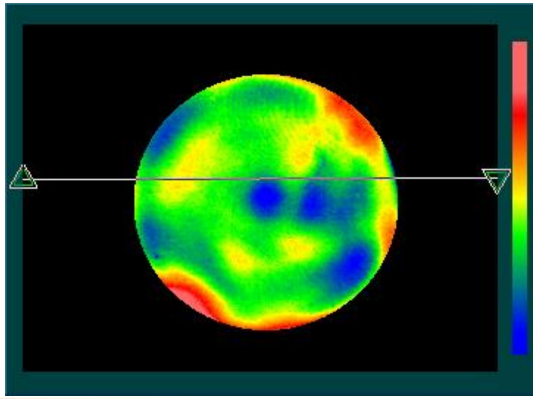
May 13th, 2026

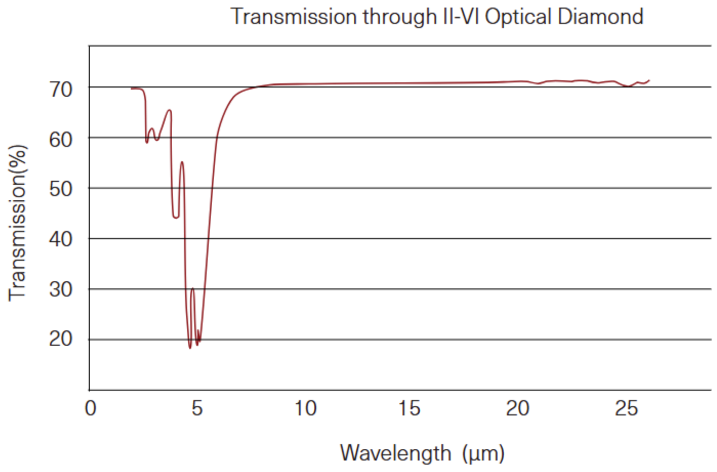
POLYCRYSTALLINE DIAMOND

- **QA + Metrology**
  - Laser Flash Analysis (Thermal Diffusivity)
  - UV-Vis/FTIR/10.6 µm Absorption
  - Microwave Loss Tangent
  - Zygo Interferometers



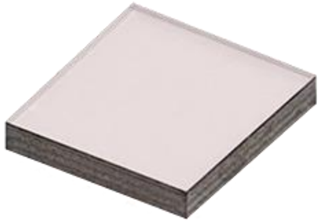




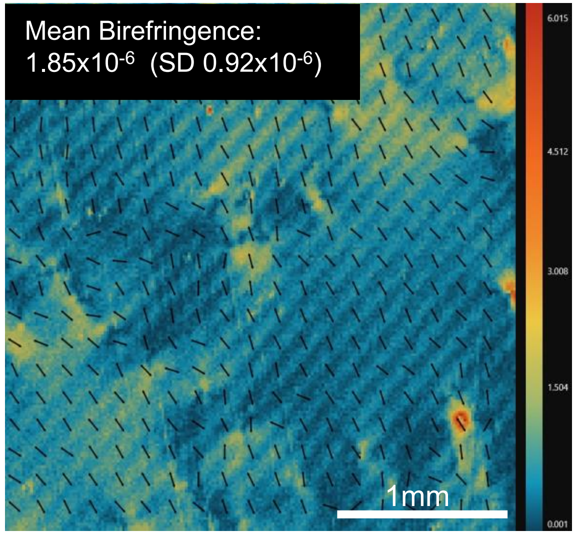


SCD-Q & SCD-Q+

- ***SCD-Q* – Coherent's first quantum grade of diamond**
  - Uniform NV distribution, ultra-low strain
  - Optimized for long room temperature T_2 – best suited for AC measurements
- ***SCD-Q+* – higher [NV] quantum grade**
  - Same ultra-low strain
  - Higher [NV] while sacrificing minimal T_2^* – best suited for DC measurements



Properties	SCD-Q	SCD-Q+
Typical $[N_s^0]$ (before irradiation)	800 ppb	14 ppm
Typical [NV]	300 ppb	4.5 ppm
Hahn Echo T_2	200 µs	10 µs
Ramsey T_2^*	1 µs	0.5 µs
Birefringence	$<10^{-5}$	$<10^{-5}$



Retardance measured with 633 nm light source, scale in nm.
Arrows denote Azimuth direction

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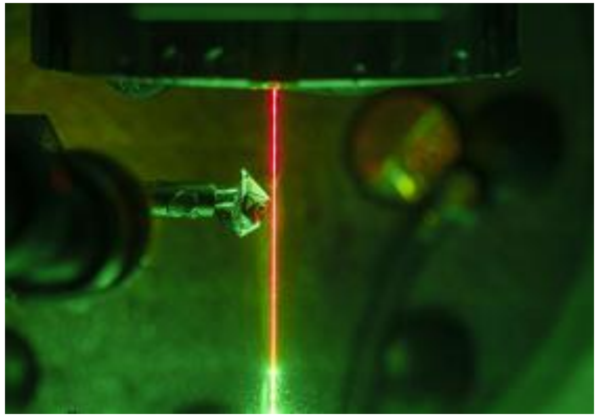
COHERENT CAPABILITIES

Saxonburg Diamond Fabrication

May 13th, 2026

COHERENT – SAXONBURG LASER OVERVIEW

- **Laser cutting and machining centers**
  - Micromachining, Cutting, Scribing, and Laser Marking
  - Many systems: multiple wavelengths, multiple pulse durations and rep rates



- Expertise processing many different material types:

Single crystal diamond	Lithium triborate	Zinc sulfide
Polycrystalline diamond	Gallium oxide	Zinc selenide
Single crystal SiC	Metal matrix composites	Germanium
Polycrystalline SiC	Silicon	Graphite
SiC composites	Polycrystalline silicon	Titanium
Glass	Metals	Gallium Nitride

…and many others!

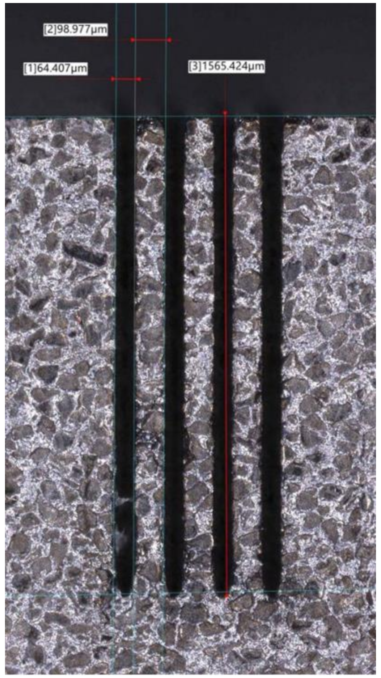
LASER MACHINING CAPABILITIES

- 3D Surfaces using gaussian and flat-top optics
- Many materials: Diamond, SiC, SiSiC, Thermadite,…
- Products for advanced semiconductor packaging processes
- Applications include structures for Liquid and Air Coolers

4H SiC

Diamond

Thermadite



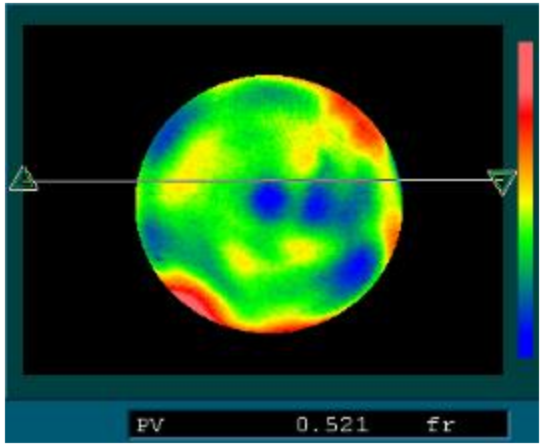
COHERENT

MATERIALS MANUFACTURING PROCESSES AND CAPABILITIES

Materials Growth → Laser Cutting & Machining → Polishing → Optical Coatings → QA Cleaning → Final Inspection and Packaging

Laser Cutting, Machining, and Marking

Advanced materials transformation capabilities



Extreme Flatness and low Roughness across large areas

Advanced Optical Measurement Capabilities

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