

OPTICS

Diamond PureOptics™



ACHIEVE EVER HIGHER POWER DENSITIES

——— *Element Six's Diamond PureOptics™ is the first all-diamond optic material, delivering 10x higher performance to enable the next generation of high power laser systems.*

elementsix™
a De Beers Group Company

THE FIRST ALL-DIAMOND OPTICS SOLUTION

The latest advancements in laser technology demand optical materials that are able to perform reliably at the ever increasing powers and higher power densities required for applications such as EUV lithography and other high power CO₂ laser systems.

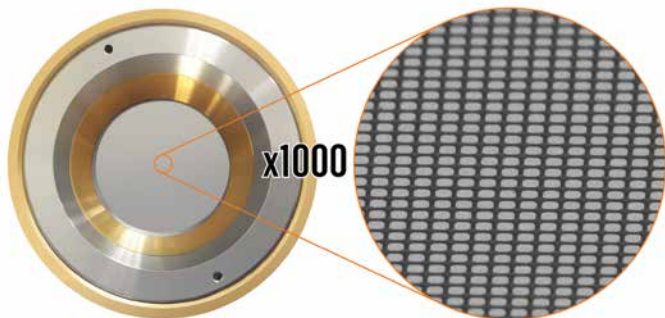
Element Six's new Diamond PureOptics™: AR window@10.6 μm is the first all-diamond optical window with anti-reflective (AR) properties built-in. This new innovation eliminates the need for performance limiting thin film AR coatings, providing engineers of next generation high power laser systems:

- Increased durability
- Improved beam quality
- Lower losses in the face of ever higher power densities
- Reduced costs associated with system downtime and replacement components

NEW META-SURFACE STRUCTURE TECHNOLOGY RELEASES DIAMOND'S FULL POTENTIAL

Optical diamond windows typically consist of an anti-reflective (AR) coating to minimise reflection losses and maximise total output power and laser induced damage threshold (LIDT). However, the mechanical and thermal properties of these coatings are 1000 times inferior to that of the diamond window itself, leading to interface failures as optical power densities increase.

Element Six has developed a new semiconductor processing technology to create meta-surface structures directly onto the diamond window. These meta-surface structures possess anti-reflective properties, eliminating any coating requirement and shifting the reliability of the optics solely onto the outstanding intrinsic properties of diamond.



Element Six Diamond PureOptics: AR@ 10.6 μm window showing the meta-surface structure under Scanning Electron Microscopy (SEM).

WHY IS DIAMOND AN IDEAL OPTIC MATERIAL?

Diamond is well established as an optical window material of choice in (>5 kW) high power CO₂ laser systems, outperforming competing materials with a superior combination of:

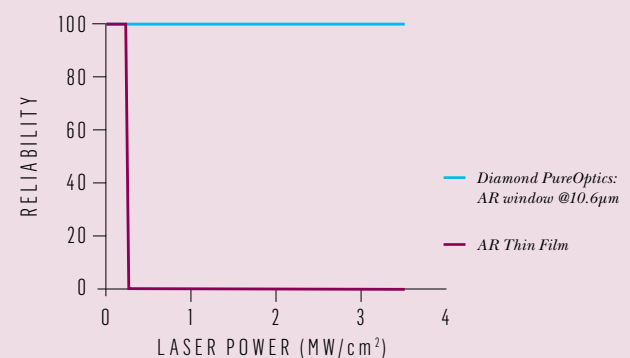
- Optical transparency
- High thermal conductivity
- Low thermal expansion coefficient
- Excellent mechanical strength
- Chemical inertness

ENABLING TEN TIMES HIGHER PERFORMANCE THAN COATED DIAMOND WINDOWS

Diamond PureOptics™: AR window@10.6 μm exhibits outstanding performance improvement over thin film AR coated windows:

- 10 x higher LIDT* (Under CW conditions)
- < 0.5% reflectance
- > 99% transmission
- Absorption coefficient @ 10.6 μm <0.07 cm⁻¹

DIAMOND PUREOPTICS™ EXHIBITS 10X HIGHER LIDT THAN AR THIN FILM COATINGS



Laser induced damage of AR coating.

TEN TIMES HIGHER PERFORMANCE FOR HIGH POWER LASER SYSTEMS

READY FOR APPLICATION

Diamond PureOptics™: AR window@10.6 μm are available single or double sided, in standard or custom mounts, for increased reliability in applications such as:

- EUV Lithography
- Cutting
- Welding
- Surface Processing
- Directed Energy
- Imaging



Faster through-put enabled by higher power densities

PRODUCTS UNDER DEVELOPMENT

Element Six's new all-diamond meta-surface technology can be developed and tailored for your specific structured surface optics needs, such as:

- Other wavelengths – progress has been made @ 1μm
- A broad wavelength range
- Quarter-wave and half wave plates
- Filters
- Polarizers

Proof of concept has been demonstrated for Quarter Wave Plate (QWP) and Half Wave Plate (HWP) by altering the pattern structure and currently developing structured optical windows for 1 μm applications



Figure 4: Trenches of equal periodicity and depth created by innovative etching technology to produce QWP

CONTACT ELEMENT SIX FOR MORE INFORMATION ON THESE DEVELOPMENT OPPORTUNITIES

DIAMOND PUREOPTICS TECHNICAL SPECIFICATIONS

SPECIFICATION	VALUE
Dimensions	60 mm diameter now (<100 mm diameter in the future)
Material Type	Polycrystalline CVD diamond (OR24, DR1, TR4 or equivalent)
Absorption Coefficient @10.6μm	<0.07 cm ⁻¹
Transmission prior to Meta-Surface structure @10.6μm	>70%
Transmission @10.6μm	>98%
Reflectance @10.6μm	<0.5% / side
Meta-surface Defect density	<0.01% (TBD)
Flatness	<1 Fringe @ 633 nm
Scatter @10.6μm	<0.7%
Fracture Toughness	5.3– 7 MPam ^{0.5}
Tensile Strength (Poly at 0.4mm thickness)	800 MPa Nuc, 400 MPa Growth
Hardness	81 ± 18GPa
Coefficient of Thermal Expansion	1.0 ppm/K @300K
Mountings	Options available on discussion

ELEMENT SIX TECHNOLOGIES

Element Six Technologies is a division of Element Six, the world's market leader in the manufacture and development of synthetic diamond, established in the 1940s.

Today Element Six is a \$500 million company operating production facilities in 7 countries and serving over 5,000 customers worldwide.

Element Six Technologies operates two production and technical facilities around the globe; Santa Clara in California, and Ascot in the United Kingdom. The new Santa Clara facility offers US based customers a state-of-the-art facility for producing CVD diamond solutions for use in a wide array of advanced industry applications including optics, power transmission, sanitization and water treatment, semiconductors and sensors.

In 2013, Element Six opened the world's largest and most sophisticated synthetic diamond supermaterials research and development facility in Oxford, UK.

If you would like to know about Element Six please visit our website at www.e6.com/optical, or contact us at any of the addresses below.

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