

## TECHNOLOGIES

*Technologies Capabilities*



# SOUNDS LIKE A DIAMOND

——— *We are always in search of opportunities to innovate and apply our synthetic diamond expertise and know-how. This led to a partnership in creating the world's first diamond tweeter dome for speaker manufacturers Bowers & Wilkins. We work with all our partners across optics, semiconductors, sensing, detecting and water sanitization applications to integrate diamond into their systems and achieve their full potential.*



# ELEMENT SIX TECHNOLOGIES

————— *Creating your competitive advantage  
with synthetic diamond in optics, semiconductors,  
sensing, detecting and water sanitizing.*

Element Six Technologies is a division of Element Six, part of the De Beers Group of Companies, and a market leader in the manufacture and development of synthetic diamond.

Element Six Technologies operates two production and technical facilities; in Santa Clara, California and in Ascot, United Kingdom, supported by research & development at our Global Innovation Centre near Oxford, United Kingdom. These state-of-the-art facilities produce CVD diamond solutions for use in a wide array of advanced industry applications including optics, thermal management, sanitization and advanced sensor technology.



# ELEMENT SIX LEADS THE WORLD IN SYNTHETIC DIAMOND INNOVATION

Element Six designs and develops advanced solutions, based on synthetic diamond, which open the way to dramatic step changes in process and end-product performance. These sometimes astonishing improvements in performance cannot be realized through the use of any other materials. The company is well established in this field having first invested in CVD technology in 1988 with commercialization taking off in the 1990s.

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

Element Six has a track record of successful partnerships with customers, providing fit-for-purpose CVD diamond solutions from initial design and development through to cost effective commercial processing. Element Six helps industry to implement CVD diamond solutions by providing subsystems and complete products that integrate the synthetic diamond in an easy-to-implement format.



*Chemical Vapour Deposition (CVD) synthetic diamond products are used for a wide range of high technology applications.*

## THE VERSATILE PROPERTIES OF CVD SYNTHETIC DIAMOND

### THERMAL

- Highest known RT thermal conductivity
- Highest known resistance to thermal shock
- Low thermal expansion coefficient

### OPTICAL

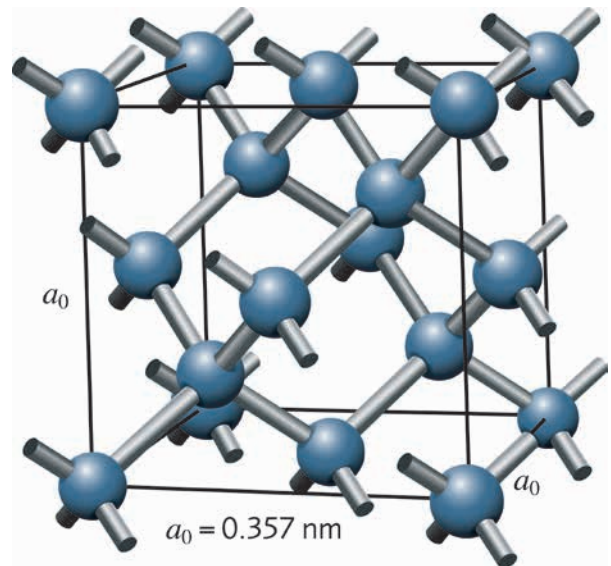
- Broad transmission spectrum

### ELECTRICAL

- Good electrical insulator
- Good electrical conductor (doped)
- Low dielectric constant
- Low dielectric loss
- Wide electronic band gap
- High electronic mobility

### INERTNESS

- High chemical (bio) inertness



*Synthetic diamond's molecular structure makes it the world's most versatile supermaterial.*

## NEW OPPORTUNITIES FOR SYNTHETIC DIAMOND

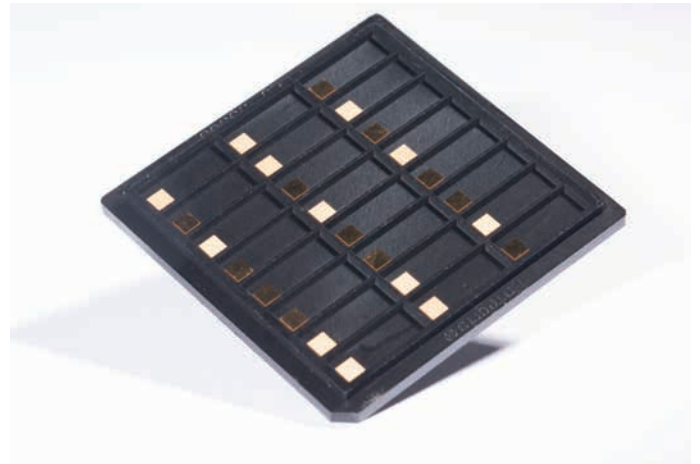
Synthetic diamond is not only regarded as the hardest material known to man, it is also the ultimate engineering material with multiple dimensions of extreme performance in the most challenging conditions.

# PROVEN APPLICATIONS FOR SYNTHETIC DIAMOND

## SEMICONDUCTORS

With the drive to increase power densities, device thermal management is an ever increasing concern. Synthetic diamond lowers device temperatures, improves reliability and expands performance capability. Element Six Technologies provides singulated heat spreaders for a broad range of device types including high power RF devices.

- Synthetic diamond reduces thermal gradients near the device, making heat sinks more efficient and allowing higher power devices to be used without increasing the system size.
- In semiconductor sub-systems synthetic diamond enables the management of higher levels of power within the existing module footprint. In effect, shrinking the size of the module for a given power requirement.
- In a sub-system of a Digital Optical Network architecture - the Photonic Integrated Circuit - synthetic diamond significantly enables increased data transmission rates.



*Delivering more semiconductor power per module or longer module life.*

## OPTICAL

Synthetic diamond delivers outstanding technical benefits in high power laser optics.

At 8 kW and over in the high power laser sector, no other material comes close to the performance of synthetic diamond. For instance, with diamond there is no need to compensate for thermal lensing, in contrast to zinc selenide.

Synthetic diamond never needs to be replaced, which ensures consistent device productivity and uninterrupted function of the application. Thermal absorption is low. Maintenance and downtime are eliminated.

Synthetic diamond optics provide the lowest cost of ownership and best performance/cost ratio of any optical material used under high power conditions.



*Outstanding benefits in high power laser optics.*

# INNOVATIVE APPLICATIONS FOR SYNTHETIC DIAMOND

## WATER TREATMENT

Synthetic diamond electrodes can be used for the treatment of industrial wastewater and landfill leachates which are difficult or impossible to treat by conventional means. This is a green technology because it requires no chemical additives.

The production of ozone by electrolysis can be made more efficient and economical with the use of long lasting synthetic diamond electrodes. Ozone is a powerful oxidant used in many industrial and consumer processes, from disinfecting hospital laundry and sanitizing swimming pools to removing yeast and bacteria from fruit, bleaching fabrics and eliminating waterborne parasites.

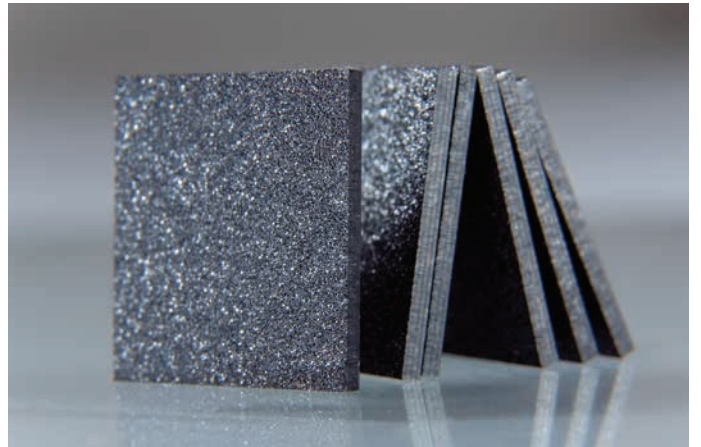


*Purifying wastewater without chemical additives.*

## ELECTROCHEMICAL SENSORS

Element Six, in conjunction with world leading academic partners, is developing a range of synthetic diamond enabled capabilities in the area of electrochemical sensing for environmental and biomedical applications.

Synthetic diamond has the potential to transform electrochemical sensing by increasing speed and sensitivity. All the unique properties of synthetic diamond; conductivity, purity, light transmission and resistance to hostile environments can contribute to greatly enhanced performance in this field.

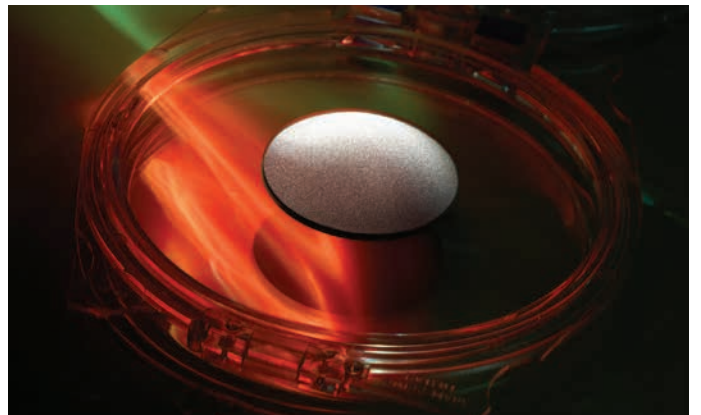


*Increasing speed and sensitivity for electro-chemical sensors.*

## SPECIAL APPLICATIONS

The long established properties of synthetic diamond, such as its unique hardness, durability and resistance to high temperatures and hostile chemical environments, are now seen as highly desirable properties in an engineering material.

The main focus of Element Six Technologies is the development of sub-systems and packages for use in large scale industrial processes. However, tomorrow's widespread technology may be the niche breakthrough of today. That is why, in partnership with Bowers & Wilkins, a leading British audio brand, Element Six developed a synthetic diamond tweeter dome which extends high frequency response and for which the development partners were jointly awarded a 2012 Queen's Award for Enterprise in Innovation.



*Synthetic diamond tweeters - Award winning performance.*

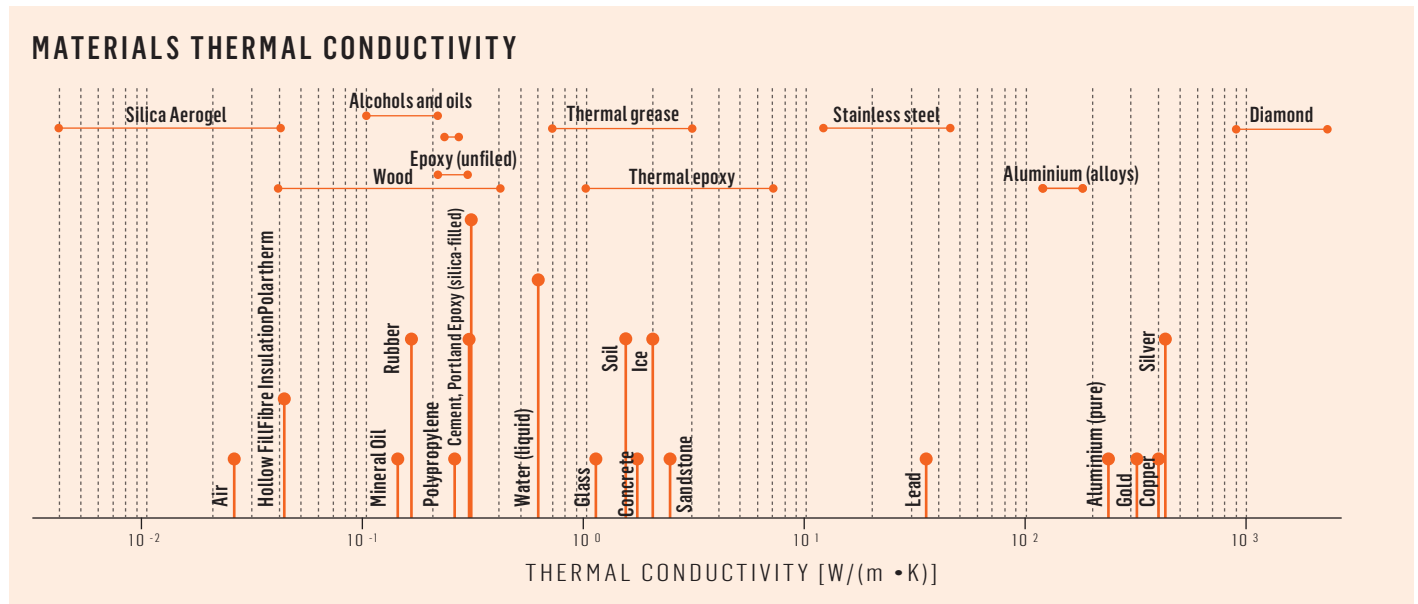
# SYNTHETIC DIAMOND TRANSFORMS PROCESSES AND PERFORMANCE

## EXTENDING APPLICATION LIFETIME

Synthetic diamond as a component material can significantly lower the operating temperature of a device or process, and that enables longer application life or higher application performance, through increased operating cycles in a given period. This is due to its exceptional thermal conductivity. The graph below compares the thermal conductivity of synthetic diamond with other materials.

## END-PRODUCT PERFORMANCE

The extraordinary properties and advantages of synthetic diamond are not confined to material science and industrial processes. They are enabling step changes in end-product performance. These changes have the potential to benefit society with improvements in sanitation and healthcare, scientific discovery, communications, the environment and the consumer digital experience. Wherever engineering materials impede technological progress, synthetic diamond may be able to improve it.



## HOW WE WORK TO ENABLE YOUR COMPETITIVE ADVANTAGE

The unique properties of synthetic diamond can enable a dramatic step-change in the cost structure of many processes and industries.

Component and material cost of ownership can achieve incremental commercial improvements unattainable through the use of any other material. For example, in some applications synthetic diamond can change useful life from days to years. Synthetic diamond also allows for sustainable competitive advantage to be realized.

In some areas, such as in electro-chemical sensing, synthetic diamond can deliver higher detection and measurement speeds and up to a 100-fold increase in sensitivity.



## ELEMENT SIX

Element Six, part of the De Beers Group of Companies, designs, develops and produces synthetic diamond and other supermaterials, and operates worldwide with primary manufacturing facilities in China, Germany, Ireland, South Africa, the UK and US.

Element Six supermaterial solutions are used in applications such as cutting, grinding, drilling, shearing and polishing, while the extreme properties of synthetic diamond beyond hardness are opening up new applications in a wide array of industries such as optics, power transmission, water treatment, semiconductors and sensors.

If you would like to know more about Element Six please visit our website [www.e6.com](http://www.e6.com) or contact us at any of the addresses below.

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