CVD DIAMOND FOR DRESSING AND CUTTING APPLICATIONS

——— The extreme properties of CVD diamond from Element Six offer toolmakers greater options for their tooling solutions.

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a De Beers Group Company

INTRODUCTION TO CVD DIAMOND

Element Six is the world leader in the synthesis of diamond by chemical vapour deposition, CVD. The company has more than 30 years' experience in this technology, and is the largest manufacturer of CVD diamond in the world. Element Six has a dedicated research and development facility committed to further improvement of CVD processes.

The CVD processes used by Element Six have enabled the development of polycrystalline and single crystal CVD diamond materials with consistent and repeatable properties. The manufacturing process is controlled to synthesise material tailored to the needs of a particular application.

CVD diamond can be manufactured in different shapes, sizes, thicknesses and grades allowing engineers to exploit the extreme properties of the material.

CVD DIAMOND SYNTHESIS

At Element Six, a microwave plasma enhanced CVD process is the main diamond synthesis route that has been developed and refined. The process relies on decomposing carbon containing gas molecules, such as methane, acetylene or carbon dioxide at subatmospheric pressure and depositing diamond as a layer on a substrate.

CVD DIAMOND MATERIAL

Polycrystalline CVD diamond has been optimised for mechanical applications. This material has a columnar structure with well-intergrown grains. It is pure diamond and has no binder phase. The grain size and structure depends on the growth conditions and the diamond grade. Current technology within Element Six enables the growth of polycrystalline material in thicknesses that range from microns to millimetres. This adds up to a range of different types and grades of CVD products suitable for different applications.

CVD (Chemical Vapour Deposition)

CVD FOR DRESSING APPLICATIONS

CVD DIAMOND PROPERTIES

Polycrystalline CVD diamond is chemically inert, has outstanding thermal conductivity, coupled with excellent wear and thermal oxidation resistance. For mechanical applications within the dressing and cutting tool sector, the key properties are:

- The hardest known material
- Fully dense
- High abrasion resistance
- Extremely chemically inert
- Low thermal expansion coefficient
- Becomes a good electrical conductor when doped
- Graphitization only at very high temperatures (>700˚C)
- High strength
- Highest resistance to thermal shock
- Good electrical insulator
- High purity material available in large areas

Element Six offers two families of CVD products developed for dressing, cutting and wear applications; CVDRESS and CVDITE.

THE ADVANTAGES OF CVDRESS

- High resistance to chipping and fracture
- Uniform wear over the entire length of the dress
- Performance independent of dresser orientation
- Excellent thermal stability independent of orientation (due to no binder phase)

CVDRESS

Within this family are CVDRESS CDD and CDM. CVDRESS CDD is a premium free-standing CVD diamond grade specifically designed for dressing and truing of grinding wheels. CDM is a grade suitable for rotary dressing applications. These products are normally supplied as rectangular logs in various lengths and cross sections though non-standard dimensions are available in both processed and non-processed (NP) versions. The NP version of these products has wider dimensional tolerances in relation to thickness though the properties of the material remain the same as the processed version.

CVDRESS CDD

This product has been specifically engineered to have a high resistance to abrasive wear in dressing applications. It is suitable for all dresser types – single point, multipoint and blade. The size of dresser chosen is determined by the application and Element Six can recommend suitable dimensions on request.

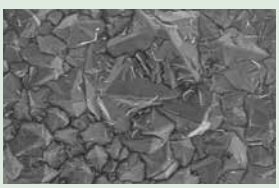
CVDRESS CDM

This product is intended for rotary dressing applications that are commonly used in high volume production form grinding. The CDM material, having no binder, offers the benefits of high resistance to abrasive wear, high thermal stability and chemical inertness.

MECHANICAL CVD GRADES

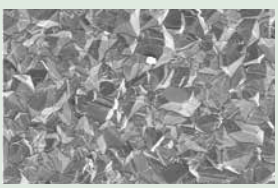
CDM

General purpose grade for cutting tools and rotary dressers.



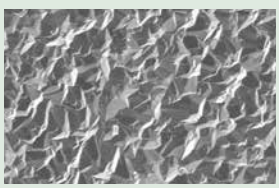
CDD

Stronger and more wear resistant grade for single point and blade dressers.



CDE

Electrically conductive grade for cutting tools which needs to be processed by EDM or EDG.



CVDRESS TOOLS

TOOL FABRICATION

With outstanding thermal properties and very high thermal oxidation resistance CVDRESS CDD & CVDRESS CDM are ideal for secure mounting when using traditional non-ferrous metal sintering. Alternatively, dressers can be brazed onto a dresser body using an active braze alloy in a non-oxidising environment.

Industry standard grinding techniques can be used to shape dressers in-situ to make cone, chisel and radiused shapes.

THICKNESS AND MATERIAL AVAILABILITY

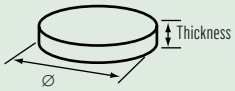
CVDRESS (DRESSING TOOLS)

CDD		CDM
CDD 02		CDM 02 NP
CDD 03	CDD 03 NP	CDM 03 NP
CDD 04	CDD 04 NP	CDM 04 NP
CDD 05	CDD 05 NP	CDM 05 NP
CDD 06	CDD 06 NP	CDM 06 NP
CDD 07		CDM 07 NP
CDD 08	CDD 08 NP	CDM 08 NP
CDD 10	CDD 10 NP	CDM 10 NP
CDD 12	CDD 12 NP	CDM 12 NP
CDD 15	CDD 15 NP	CDM 15 NP
	CDD 20 NP	CDM 20 NP

DEFINITIONS

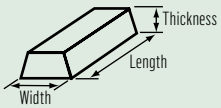
Thickness defined as; 02 = 0.2 mm, 03 = 0.3 mm etc..
Standard surface finish is lapped to remove growth features.
NP is defined as unprocessed material. The surface finish is either 'as grown' or with any finish to meet the specified thickness.

NOMENCLATURE EXAMPLES



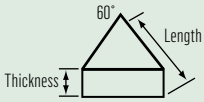
CDD R

CDD R2608-360 is a CDD grade 'round', 2.6 mm in diameter and 0.8 mm thickness



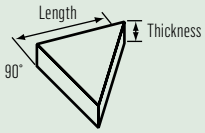
CDD L

CDD L500808NP is a CDD grade 'log', 5mm in length, 0.8mm wide, 0.8mm thickness and having an unprocessed surface finish



CDD T

CDD T3015-60 is a CDD grade equilateral triangle having 3.0 mm edge length and 1.5 mm thickness



CDM T

CDM T3015-90 is a CDM grade, 90° triangle having two 3.0 mm edges and 1.5 mm thickness

A minimum order charge may be incurred for small volumes of new parts.

CVD FOR CUTTING TOOL & WEAR APPLICATIONS

CVDITE

Especially developed for cutting tool applications, CVDITE has been engineered to complement PCD and Monocrystal materials for defined edge tooling and is available as CVDITE CDE or CVDITE CDM.

CVDITE CDE

CVDITE CDE is an electrically conducting grade for cutting tools where the customers use electrical discharge machining (EDM) or electrical discharge grinding (EDG) within their tooling processing.

CVDITE CDM

CVDITE CDM is a general purpose mechanical grade for cutting tools. Both are available in a thickness of 0.5 mm with a polished finish.

CVDITE has a high resistance to abrasive wear, high thermal stability, and (since it is binder-free) is chemically inert. The high thermal conductivity makes it an ideal tool material for those applications where higher temperature operating conditions are seen, in particular, dry machining of metal matrix composites and high volume fraction glass fibre (or carbon) reinforced materials.

The polished top face of CVDITE can contribute to improved cutting edge quality and better chip flow characteristics or for wear parts to reduce friction. Intended particularly for dry cutting applications, the corrosion resistance of the CVD diamond makes it also suitable for use with coolant without any detrimental effects on the diamond.

CVDITE is generally recommended for machining non-ferrous materials where high abrasion resistance is required. CVDITE has high thermal stability and more wear resistance than PCD.

TYPICAL EXAMPLES OF WORKPIECE MATERIALS INCLUDE:

- Laminated flooring,
- Fibreboard and cement board
- Metal matrix composites
- Aluminium alloys
- Glass-reinforced plastics and carbon fibre-based materials
- Plastics and rubbers
- Graphite

Due to its high abrasion resistance and low coefficient of sliding friction, the CVDITE range is also ideal for uses in lubricated and dry wear part applications.

CVDITE TOOLS

TOOL FABRICATION

Synthesised as flat plates, CVDITE is processed to the exacting requirements and high standards of the diamond toolmaking industry. The product range covers tool blanks in various formats, shapes and sizes for the tipping of cutting tools and wear parts using typical tool fabrication techniques developed for natural diamond and Monocrystal diamond.

Products are normally prepared with one fine lapped surface, which is preferred for bonding. Brazing to tungsten carbide substrates can be carried out in a vacuum furnace or reducing gas atmosphere, using high temperature active braze alloys. The highly polished face is recommended to be used as the top table or rake face of the tool as this is beneficial in producing a sharp, chip-resistant cutting edge.

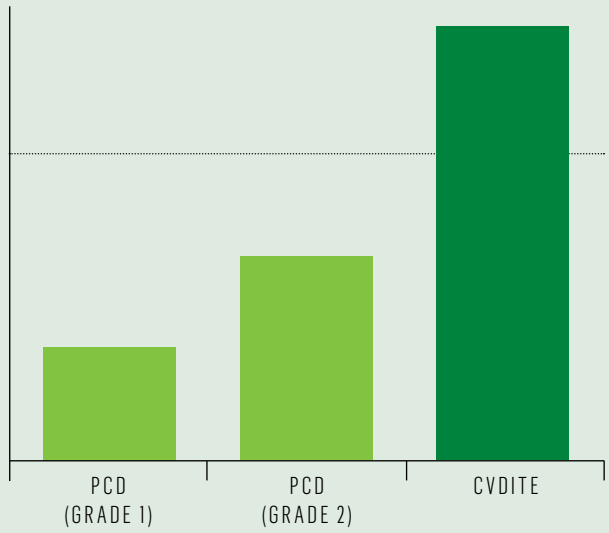
THICKNESS AND MATERIAL AV AILABILITY

CVDITE (CUTTING TOOLS)	
CDE	**CDM**
	CDM 02 PL
CDE 05 PL	CDM 05 PL

DEFINITIONS

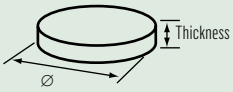
Thickness dimensions are defined as; 02=0.2 mm, 05= 0.5 mm. The standard surface finish has a polished face (Ra<100nm) and a lapped face (Ra<400nm) designated with the suffix PL. Unprocessed material is also available- designated NP. The surface finish of NP is either 'as grown' or with any finish to meet the specified thickness.

RELATIVE TOOL LIFETIME IN THE MACHINING OF MMCS



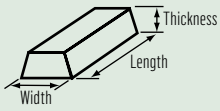
In applications where tool wear is dominated by abrasive wear CVD has been observed to show greater abrasion resistance compared to PCD. Therefore CVD is particularly suitable for highly abrasive continuous turning operations.

NOMENCLATURE EXAMPLES



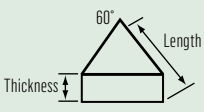
CDE R

CDE R2605-360PL is a CDE grade 'round', 2.6 mm in diameter and 0.5 mm thickness



CDE L

CDE L603005PL is a CDE grade 'log', 6mm in length, 3.0mm wide, 0.5 mm thickness.



CDM T

CDM T3005-60PL is a CDM grade equilateral triangle having 3.0 mm edge length and 0.5 mm thickness

A minimum order charge may be incurred for small volumes of new parts.

GIVING TOOLMAKERS GREATER OPTIONS FOR THEIR TOOLING SOLUTIONS

The CVD range of products developed by Element Six for wheel dressing and cutting tool applications gives the toolmaker greater options for their tooling solutions. The overall benefits offered by CVD diamond add up to high abrasion resistance that suits all types of dressing and cutting applications, combined with high purity, high thermal conductivity and good thermal stability.

MECHANICAL PROPERTIES OF CVD DIAMOND

PROPERTIES	CDM AND CDD	MONOCRYSTAL 1B MATERIAL	MEDIUM GRAINED PCD
Density (g/cc)	3.52	3.52	4.12
Hardness (GPa)	85 - 100	50 - 100	50 - 75
Fracture Toughness (MPa.m $^{1/2}$)	8.5	3.4	8.8 - 9.0
Young's Modulus (GPa)	1000 - 1100	1000 - 1100	770 - 800
Poisson's Ratio	0.07	0.07	0.07
Tensile Strength (Mpa)	560 - 1100 (Growth - Nucleation)	1050 - 3000 (Orientation Dependent)	1260
Transverse Rupture Strength (GPa)	1.3	2.9	1.2
Compressive Strength (GPa)	9.0	9.0	7.4 - 7.6

THERMAL PROPERTIES OF CVD DIAMOND

PROPERTIES	CDM AND CDD	CDE	MONOCRYSTAL 1B MATERIAL	MEDIUM GRAINED PCD
Thermal Conductivity				
@ 20°C (W/m.K)	1000 - 1200	400 - 500	800 - 1400	500 - 560
@ 200°C (W/m.K)	800 - 900	300 - 400	500 - 900	200
Electrical Resistivity				
Max	Electrical	0.0007 Ωm	Electrical	0.00009 Ωm
Min	Insulator	0.0005 Ωm	Insulator	0.00006 Ωm
Thermal Expansion Coefficient				
100°C - 250°C(ppm/K)	1.3 - 2.1	1.3 - 2.1	1.3 - 2.1	4.2
500°C (ppm/K)	2.8 - 3.0	2.8 - 3.0	2.8 - 3.0	
750°C (ppm/K)	3.5	3.5	3.5	6.3

ELEMENT SIX

Element Six is a synthetic diamond supermaterials company and a member of the De Beers Group of Companies.

Element Six designs, develops and produces synthetic diamond supermaterials, and operates worldwide with its head office registered in Luxembourg, and primary manufacturing facilities in China, Germany, Ireland, South Africa, US and the UK.

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 already 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 at www.e6.com.

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