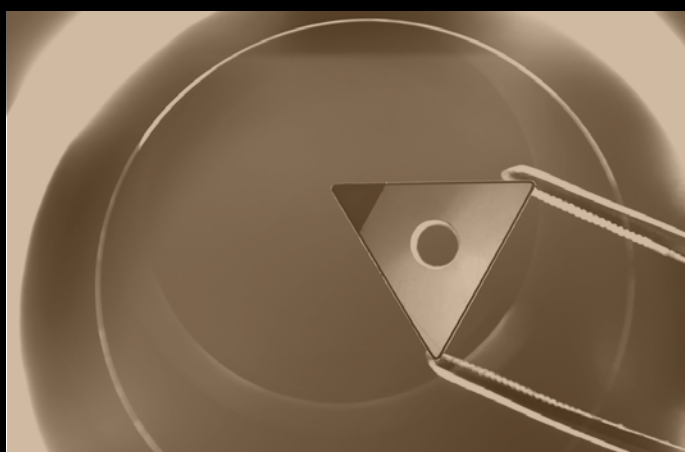


GIVING TOOLMAKERS A COMPETITIVE EDGE WITH PCD, PCBN, CVD DIAMOND & SINGLE CRYSTAL DIAMOND



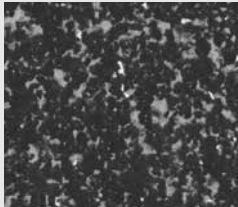
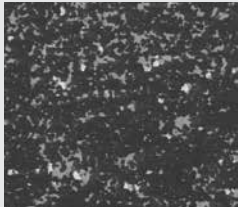
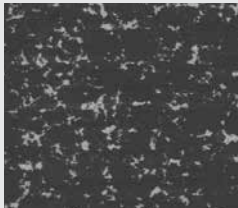
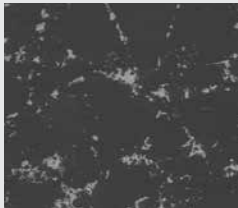

A PARTNER FOR SUCCESS

Element Six works in partnership with customers to develop cutting-edge products and materials that offer considerable advantages over their competitors. Element Six has a proven commitment and capacity to innovate and continues to deliver ground breaking commercial opportunities.

The unique Element Six state-of-the-art Global Innovation Centre (GIC) near Oxford (UK), further enhances our position as the world leader in synthetic diamond and supermaterials research to find new ways to turn the extreme properties of supermaterials into products with revolutionary performance.

Element Six welcomes customers to collaborate with us to develop their next generation products at the GIC. Not only can we deliver unprecedented levels of product performance for customers, but we can bring these proven innovations to market within a short timescale.

PCD GRADES AND CHARACTERISTICS

GRADE	APPLICATIONS	CHARACTERISTIC	MICROSTRUCTURE
CMX850	Ideal for milling and rough cutting of aluminium alloys where extreme chip resistance is required, also for machining titanium and composites.	Sub-micron grain size. CMX850 ultra-fine grain structure is suitable for applications where mirror finishes are required due to its extreme edge sharpness/retention.	
CTX002	Ideal for profile routers and thread cutting tools, can also be used in wear part applications.	2µm average grain size with increased cobalt for ease of processing. CTX002 is ideal for complex tools where excessive processing is required.	
CTB010	The ideal grade where roughing and finishing are performed with a single tool. Highly recommended for low – medium content aluminium alloys.	10µm average grain size, CTB010 is the workhorse PCD grade ideal for many applications where a good balance of toughness and wear resistance is required.	
CTH025	Successful in machining of high silicon aluminium alloys, metal matrix composites (MMC), tungsten carbides and ceramics.	Average grain size of 25µm, CTH025 offers the optimum wear resistance for abrasive machining conditions.	
CTM302	Application areas include MMC, high silicon aluminium alloys, high strength cast irons and bi-metal applications. Excellent abrasion resistance and good thermal stability.	A multi-modal PCD with grain sizes of 2µm to 30µm which give CTM302 excellent wear resistance, edge strength and edge quality.	

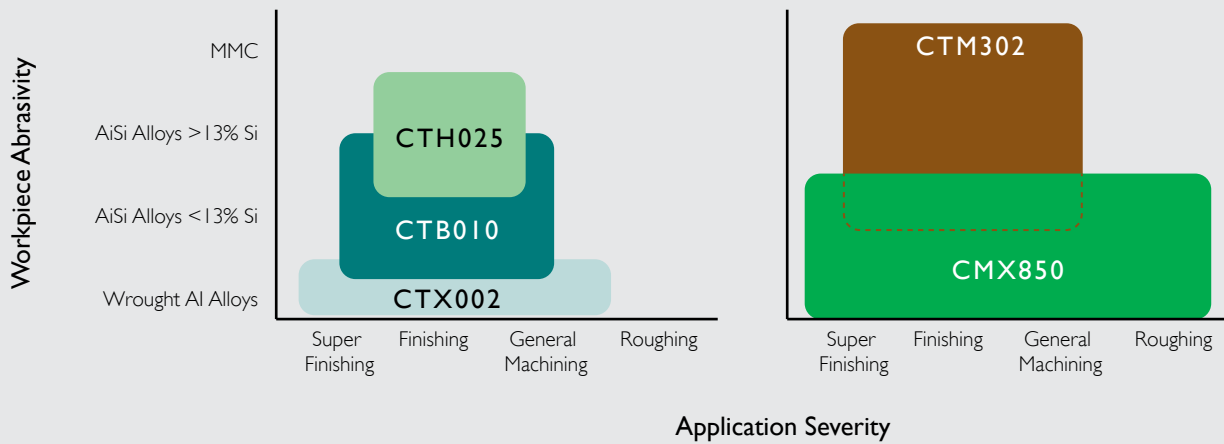
BENEFITS OF ELEMENT SIX PCD

- Consistent uniform wear, excellent thermal stability and ultimate wear resistance
- Delivers unparalleled part quality over long production runs
- Minimises machine down-time
- Ease of use in tool fabrication
- The greatest selection of PCD for the precision tooling industry

CHOOSING THE RIGHT PCD GRADES

PCD GRADES FOR WIDER USAGE

Improvements in synthesis techniques coupled with new product development capability has resulted in CMX850 and CTM302 having the properties to meet all of the challenges in tool performance. CTM302 provides the ultimate abrasion resistance while CMX850 provides the optimum balance of processability and performance.



THE 4 MAIN FACTORS FOR CONSIDERATION WHEN SELECTING PCD GRADES:

- Chip resistance
- Abrasion resistance

} Behaviour in Application

- Electro-discharge characteristics
- Grindability characteristics

} Processing Characteristics

MATERIALS AND MACHINING

Element Six PCD grades provide the ideal balance between behaviour in application and processing characteristics to meet the requirements of the cutting or grinding operation.

Grade	Grain Size	BEHAVIOUR IN APPLICATION		PROCESSING CHARACTERISTICS	
		Chip Resistance	Abrasion Resistance	Electro-discharge Machinability	Grindability
CMX850	0.5-1.0µm	████████████████████	██████████████████	████████████████████	████████████████████
CTX002	2µm	██████████████████	██████████████████	████████████████████	██████████████████
CTB010	10µm	██████████████████	██████████████████	██████████████████	██████████████████
CTH025	25µm	██████████████████	██████████████████	██████████████████	██████████████████
CTM302	2-30µm	██████████████████	██████████████████	██████████████████	██████████████████

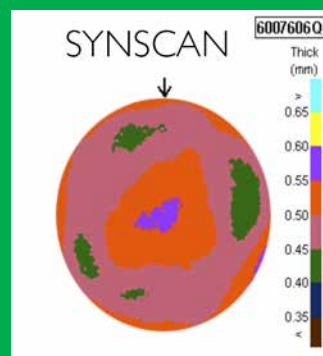
PCD PRODUCT RANGE

SPECIFICATIONS FOR STANDARD PCD DISC

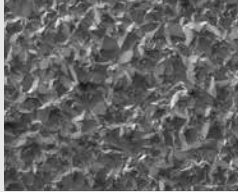
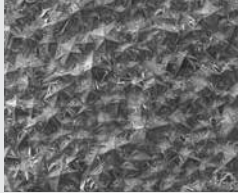
Grade	Outside diameter (mm)	PCD usable area (mm)	PCD layer (mm)	Overall thickness (+/- 0.05mm)				PCD layer thickness specification (mm)
				1.6	2.0	3.18	8.0	
CTX002	76	70	0.5	✓	✓	✓		0.40 to 0.60
CTB010	76	70	0.3	✓	✓			0.20 to 0.45
	76	70	0.5	✓	✓	✓		0.40 to 0.60
	76	70	0.7	✓	✓	✓	✓	0.53 to 0.88
	76	70	1.0			✓		0.88 to 1.13
CTH025	76	70	0.5	✓	✓	✓		0.40 to 0.60
CTM302	76	70	0.5	✓	✓			0.40 to 0.60
	76	70	0.7			✓	✓	0.53 to 0.88
	76	70	1.5			✓	✓	1.35 to 1.80
CMX850	76	70	0.3	✓	✓			0.20 to 0.45
	76	70	0.5	✓	✓			0.40 to 0.60
	76	70	1.0			✓	✓	0.88 to 1.13

PCD LAYER PROFILE

Element Six supplies a unique ultrasonic scan depicting the PCD layer profile. The PCD scan indicates a 'North Point', which matches a 'North Point' laser marked on the disc, allowing users to optimise the cutting areas.



CVD DIAMOND GRADES AND CHARACTERISTICS

GRADE	APPLICATIONS	CHARACTERISTIC	MICROSTRUCTURE
CDE PL	Application areas are the machining of laminated flooring, fibre and cement boards.	An electrically conducting grade of CVD for cutting tool applications, that allows customers to use EDM machining or EDG grinding within their tooling processing.	
CDM PL	Successful in the machining of metal matrix composites, aluminium alloys, glass reinforced plastics and carbon fibre based materials.	A general purpose mechanical grade for cutting tools.	

BENEFITS OF ELEMENT SIX CVD DIAMOND: CVDITE

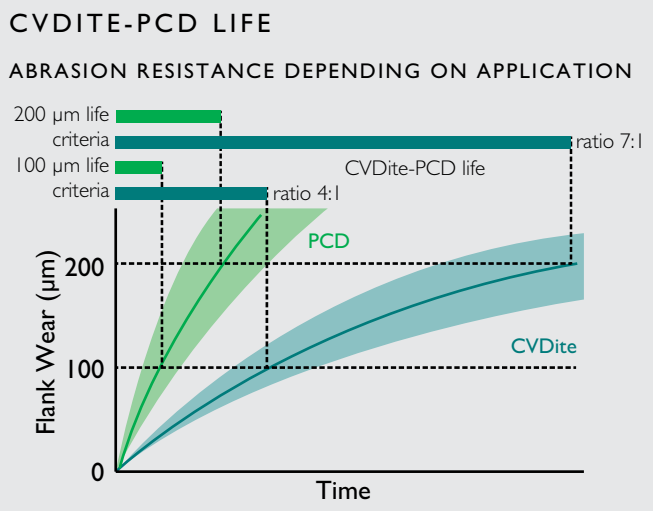
- Higher wear resistance than medium PCD grades
- Excellent thermal stability and thermal conductivity
- Binder-free so is extremely chemically inert
- Extreme abrasion resistance
- Ideal for applications where higher temperature operating conditions are seen
- High purity

Grade	Grain Size	BEHAVIOUR IN APPLICATION		PROCESSING CHARACTERISTICS	
		Chip Resistance	Abrasion Resistance	Electro-discharge Machinability	Grindability
CDE	60-80µm				
CDM	60-80µm			N/A	
CTB010	10µm				

CHOOSING THE RIGHT CVDITE GRADE

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

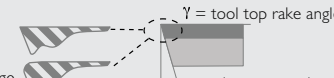
Due to its high abrasion resistance and low coefficient of sliding friction, the CVDITE range is also ideal for uses in lubricated and dry wear part applications.



SELECTING ELEMENT SIX PRODUCTS & GRADES FOR YOUR APPLICATIONS

		PCD / CVD GRADE SELECTION						CUTTING DATA AND EDGE DESIGN							
		CMX850	CTX002	CTB010	CTH025	CTM302	CDM	CDE	Cutting Speed (m/min)		Feed, f (mm) fz (mm/insert)	Depth of Cut a _p (mm)	Typical Edge Geometries		
								10	100	200	500	1000	5000		
Non Ferrous Metals Hypoeutectic (Si < 12%) and eutectic (Si = 12%) silicon alloys	N	N01	█	█	█	█			█		0.1-0.4	0.1-4.0	F α = 7-20° γ = 0°/+6°		
		N10	█	█	█	█			█						
		N20	█	█	█	█			█		0.1-0.3	0.1-3.0			
		N30	█	█	█	█			█						
Hypereutectic (Si > 12%) Aluminium casting alloys Metal matrix composites (MMC)	N	N01	█		█	█	█	█	█		0.1-0.5	0.1-4.0	F/E α = 7-11° γ = 0°/+6°		
		N10	█		█	█	█	█	█						
		N20	█	█	█	█	█	█	█		0.1-0.3	0.1-3.0			
		N30	█	█	█	█	█	█	█						
Ceramic machining (green) Ceramic machining (sintered)	N	unsintered	█			█	█	█		0.1-0.4	0.2-1.0	F/E α = 0-7° γ = 0°/-6°			
		sintered	█			█	█	█		0.1-0.25	0.1-0.5				
Copper and its alloys Magnesium and its alloys	N	N01	█	█	█			█		0.03-0.3	0.05-2.0	F α = 7-11° γ = 0°/+6°			
		N30	█	█	█			█							
Bi metals	N K	N20		█	█	█		█		0.08-0.2	0.25-1.0	F/E α = 7-11° γ = 0°/+6°			
Grey & High Strength Irons	K	K01 K40			█	█	█	█	█		0.08-0.2	0.25-1.0	F α = 7-11° γ = 0°/+6°		
Composite Plastics		01 20	█	█		█	█	█		0.1-0.2	0.2-3.0	F/E α = 7-11° γ = 0°/+6°			
Titanium	S	S01 S30	█	█	█			█		0.1-0.2	0.2-0.5	F/E α = 7-11° γ = 0°/+6°			

Work material characteristics and to a lesser extent, cutting parameters, determine the demands placed on the cutting tool and hence, the optimum balance of tool material properties. Knowledge of the application, including workpiece composition, facilitates selection of the optimum grade and selection of the correct tool geometry. Often, work material composition and machining parameters (v_c, f, a_p) go hand in hand. It is possible, therefore, only to provide a typical range of values for each parameter.

LEGEND
 F=up-sharp
 E=honed edge


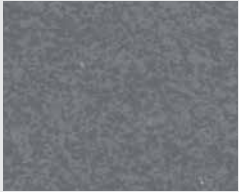
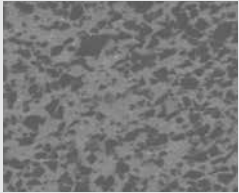
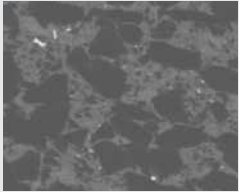
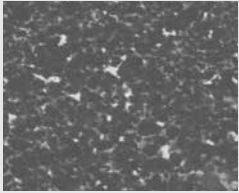
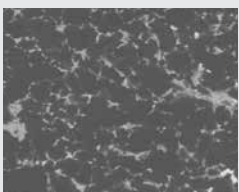

SINGLE CRYSTAL DIAMOND

GRADE	APPLICATIONS	CHARACTERISTIC
SINGLE CRYSTAL MCC	MCC offers superior edge quality for ultra-precision machining operations, as well, as extreme wear resistance in abrasive applications generating very high surface finishes.	Produced under ultra-high purity conditions, which gives it its colourless appearance. It offers a combination of extreme wear resistance, excellent chip resistance and high thermal conductivity combined with low thermal expansion.
MONODITE	Primary applications for Monodite are engineered cutting tools and wear parts for super finishing, burnishing, wire guides and ultra-precision machining.	Manufactured using a proprietary high pressure, high temperature synthesis process and is pale yellow in colour. The result is a single crystal synthetic diamond that is highly consistent and has predictable properties / behaviours, offering an unrivalled choice of synthetic diamond required for cutting tool applications.



BENEFITS OF ELEMENT SIX SINGLE CRYSTAL	
<ul style="list-style-type: none"> – Highly consistent, predictable properties and behaviour – Unrivalled surface finish and component accuracy performance unattainable with conventional polycrystalline tool materials 	<ul style="list-style-type: none"> – Surface roughness values are of the order of nanometres and form accuracies are commonly sub-micron – Facilitates the manufacture of cutting tools with edge roughness and sharpness values in the order of 10 nm and form accuracies in the micrometre range

PCBN GRADES AND CHARACTERISTICS

GRADE	APPLICATIONS	CHARACTERISTIC	MICROSTRUCTURE
DCN450	For moderately interrupted hard turning and finish hard milling, also in high-speed continuous turning, its resistance to crater wear is among the highest in the market.	CBN content approximately 45%, a sub- μm CBN grain size and a TiCN binder. DCN450 has one of the finest structures of all commercial grades and therefore provides for sub- μm surface roughness (RZ).	
DCC500	For continuous and lightly interrupted cutting of the majority of automotive steels, excellent abrasion resistance making it the ideal choice for cold work tool steels and certain valve seat alloys.	CBN content approximately 50%, the average grain size is 1.5 μm and the binder is principally TiC.	
DCX650	Recommended for moderate to heavy interrupted turning of all common hardened steels. A balance of toughness provides good resistance to crater and flank wear.	CBN content approximately 65%, a proprietary multi-modal grain size distribution with an average of 3 μm . A TiCN binder system is employed.	
DBW85	A diverse range of applications such as grey iron fine boring and valve seat machining can be attributed to excellent strength and abrasion resistance. Extreme chip resistance ideal for heavily interrupted cutting of all hard and abrasive workpiece materials.	CBN content approximately 85% with an average grain size of 2 μm . An AlWCoB binder for extreme chip resistance.	
DBS900	The ideal choice for applications where a longer tool life is required. Excels in the interrupted machining of grey and hard cast irons, hardened steels and high-alloy sintered irons and powder metals and in the majority of high-CBN application areas.	Contains approximately 90% CBN with an average grain size of 4 μm . Developed with a completely novel binder system to provide the ultimate abrasion and chip resistance.	
AMB90 (SOLID PCBN)	For turning and milling grey and hard cast iron, heavy turning of hardened steels. The solid format provides a more economical tooling solution (with useable edges on both faces of the insert).	Contains 90% CBN with a 10 μm grain size. The binder phase comprises aluminium nitrides and borides.	

BENEFITS OF ELEMENT SIX PCBN

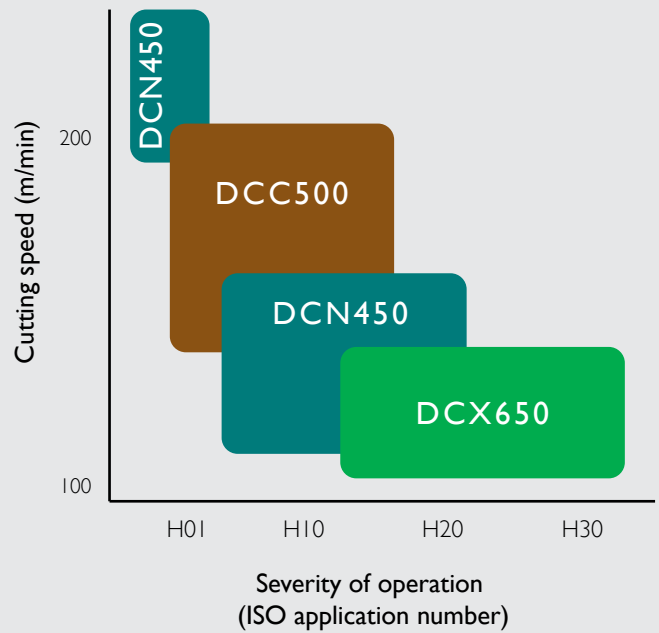
- Extremely hard and thermally stable
- Provides extreme resistance to deformation and wear at high temperatures
- Offers a viable, more cost effective alternative to conventional grinding processes
- Six different grades of PCBN to meet specific application requirements

CHOOSING THE RIGHT PCBN GRADES

APPLICATIONS FOR LOW CBN GRADES

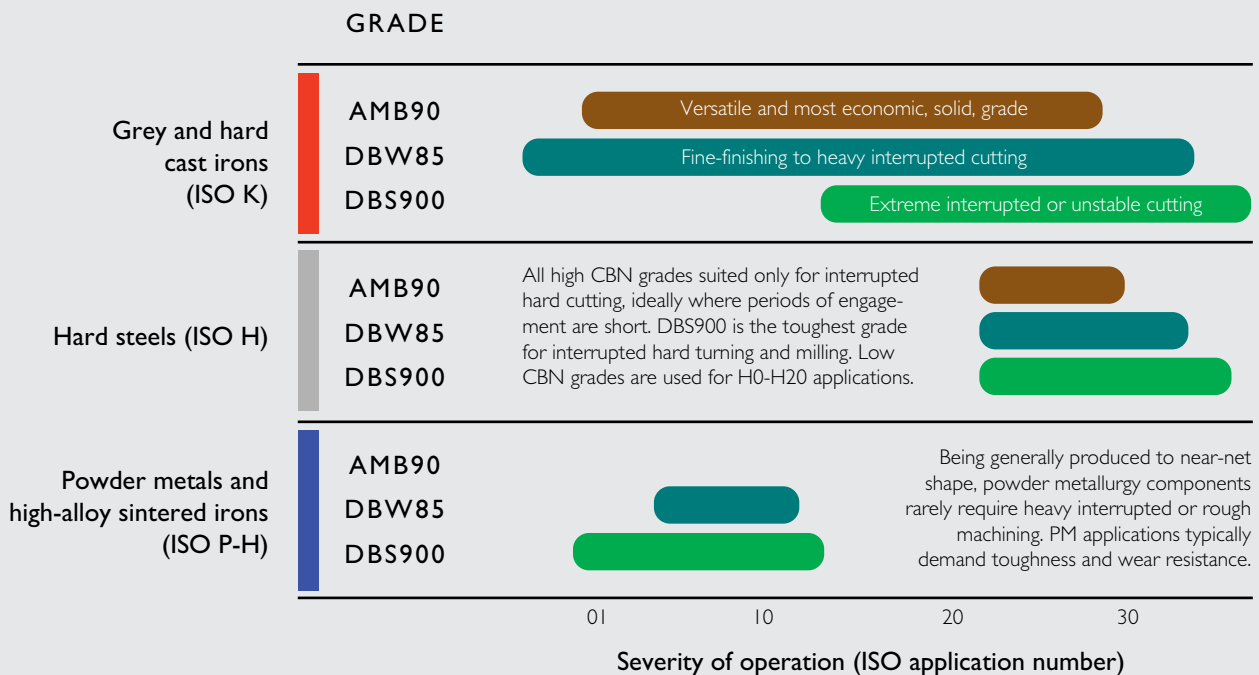
Low-medium content PCBN tooling materials are the obvious choice for machining hardened structural, bearing and tool steels. Low CBN grades are used for H0-H20 applications.

Lower-CBN content materials (grades such as DCC500 and DCN450) are resistant to chemical wear mechanisms prevalent when continuously turning hardened steels. Where there are interrupts in the work piece – oil-holes in a shaft, for example – a medium content grade like DCX650 is preferred.



APPLICATION AREAS FOR HIGH CBN GRADES

Cutting speeds vary considerably between each of the application areas and in particular between grey and hard cast irons. The more detailed grade selection chart below provides more details.



PCBN PRODUCT RANGE

EXACT SPECIFICATIONS FOR THE STANDARD PCBN DISC

PCBN WC BACKED DISC PRODUCT RANGE

Grade	Outside disc diameter (mm)	PCBN usable area (mm)	PCBN layer (mm)	Overall thickness (+/- 0.05mm)				PCBN layer thickness specification (mm)
				1.6	2.38	3.18	4.76	
DCN450	76	70	0.8	✓	✓	✓	✓	0.7 to 1.0
DCC500	76	70	0.8	✓	✓	✓	✓	0.7 to 1.0
DCX650	76	70	0.8	✓	✓	✓	✓	0.7 to 1.0
DBW85	76	70	0.8	✓	✓	✓	✓	0.7 to 1.0
DBS900	76	70	0.8	✓	✓	✓	✓	0.7 to 1.0

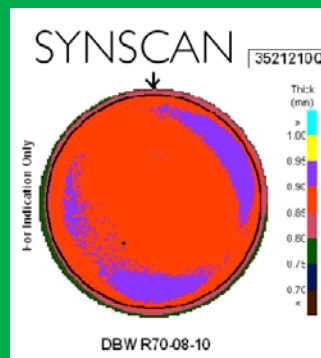
PCBN SOLID DISC PRODUCT RANGE

Grade	Outside disc diameter (mm)	Usable area (mm)	3.18mm	4.76mm	6.35mm	Total thickness specification (mm)
AMB90	97	97	✓	✓	✓	+/- 0.130

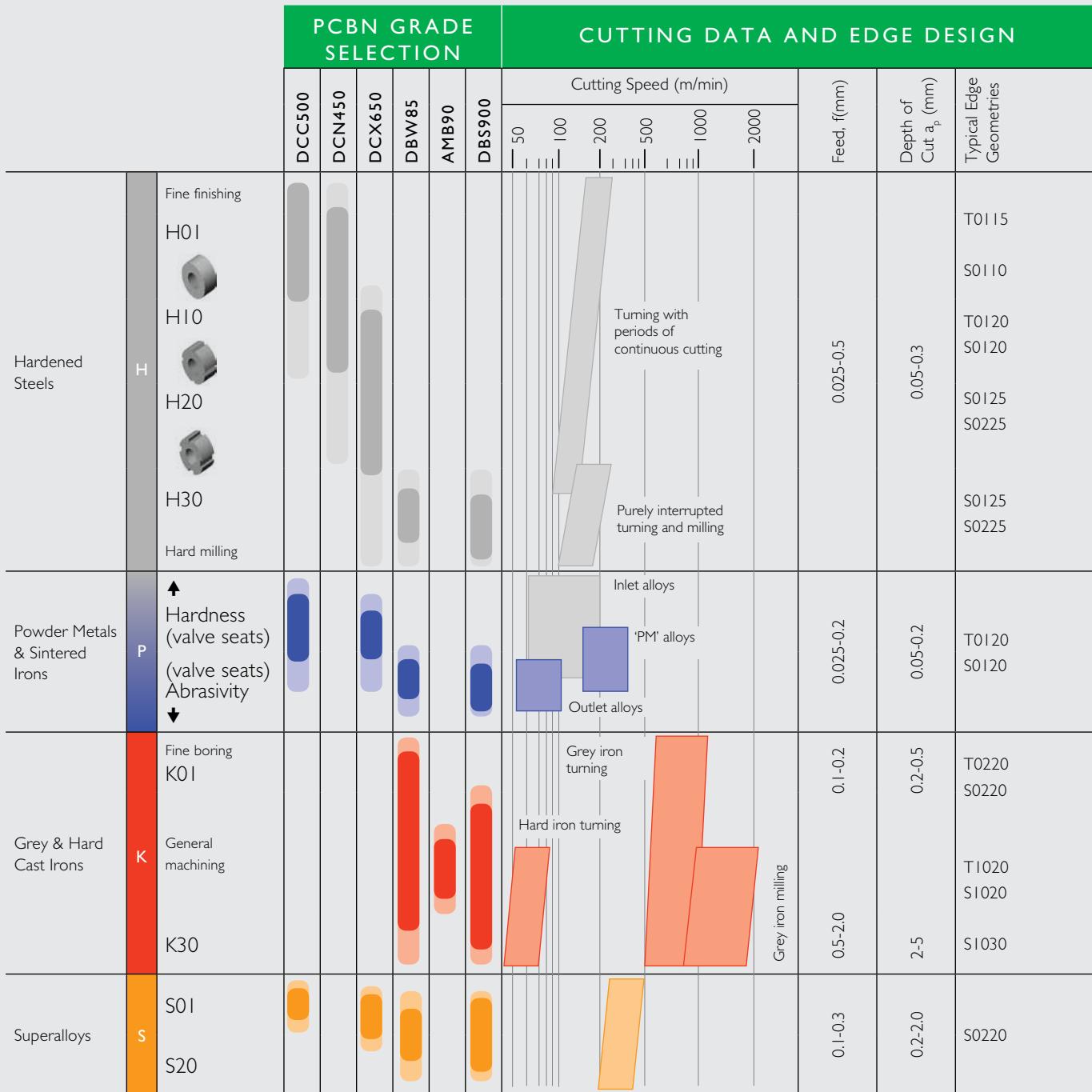
PCBN SYNSCAN

Element Six supplies a unique ultrasonic scan depicting the PCBN layer profile.

The PCBN scan indicates a 'North Point', which matches a 'North Point' laser marked on the disc, allowing users to optimise the cutting areas.



SELECTING PCBN PRODUCTS AND GRADES FOR YOUR APPLICATIONS



Work material characteristics and to a lesser extent, cutting parameters, determine the demands placed on the cutting tool and hence, the optimum balance of tool material properties. Knowledge of the application, including work piece composition, facilitates selection of the optimum grade and of the correct tool geometry. Often, work material composition and machining parameters (v_c , f , a_p) go hand in hand and the vast majority of hardened steel automotive components only require finish machining. It is possible, therefore, only to provide a typical range of values for each parameter.

Performance for grey cast irons can vary depending on casting ageing and quality.
Superalloys - PCBN is suited to Ni and Co based alloys.

ISO513 standardises the application areas for hard cutting tools and not cutting tool materials.
PCBN grades are designed for the same specific application areas and hence are best selected using the ISO-standardised application system.

CONTACT US

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BEYOND HARDNESS

Synthetic diamond has many extreme properties beyond being the hardest material, including the broadest optical transmission spectrum, the highest known thermal conductivity, a wide electronic band gap and the highest known resistance to thermal shock.

In partnership with our customers, Element Six is focussed on capitalising upon these extreme properties, delivering application solutions which ultimately give our customers the potential to realise sustainable competitive advantage in their markets.

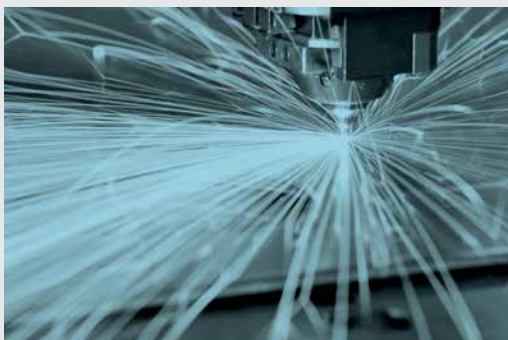
Today Element Six Technologies designs and develops advanced solutions, based on synthetic diamond, which open the way to dramatic step changes in process and end-product performance in a wide array of advanced industry applications:

- Optics
- Sanitisation and water treatment
- Electronics
- Sensing and detection

These sometimes astonishing improvements in application performance cannot be realised through the use of any other materials.



Microwave CVD diamond used in data transmission systems can lower systems temperatures, improve reliability and expand performance capability.



Microwave CVD diamond is emerging as a supermaterial with an extraordinary array of electro-optical properties.



Microwave CVD diamond purifies wastewater without chemical additives.



Microwave CVD diamond can be utilized as fast and ultra-sensitive electro-chemical sensors within bio-medical applications.

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, Sweden, 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.

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