UKAM Industrial Superhard Tools **Division of LEL Diamond Tools International, Inc.**
28231 Avenue Crocker, Unit 80 Valencia, CA 91355 USA
Phone: (661) 257-2288 Fax: (661) 257-3833 www.ukam.com

SMART CUT™ 4002 SECTIONING SAW - Operating Instructions

***SMART CUT*™ 4002 Sectioning Saw with vice assembly, gravity weight feed, & plexiglass cover**

FOR ADVANCED MATERIALS, OPTICS, COMPOSITES, METALS & MANY OTHER MATERIALS

Cutting Action:

Linear blade feeds into work piece. Material is slowly feed into the rotating blade.

Motor Power: 1/4 HP

RPM's (Variable Speed)

400-3,400 rpm

Blades SMART CUT 4002 can accommodate:

Wafering Blade Diameters:

3" to 5" (75-125mm)

Abrasive Blade Diameters:

3" to 5" (75-125mm)

Blade Thickness: .005" to .075"

Can be used with:

- SMART CUT Diamond Wafering Blades
- Other manufacturers Diamond Wafering Blades
- Abrasive Cut Off blades.

Coolant Capacity: ¼

Arbor: 5/8" or ½" (15.8 or 12.7mm)

Designed for Fast & Precision sectioning of printed circuit boards, ceramic substrates, electronic packages, and many other materials. Precision saw combined with longer sample sectioning capability. Can be used for precision applications and for general low deformation, low kerf loss sectioning. SMART CUT 4002 has largest work surface area than any other saw in its class. Designed to accommodate oversize samples.

Compare to any other low or high speed brand name Sectioning / Wafering Saw. ***SMART CUT*™ 4002** is able to withstand more exploitation, requires less maintenance, and much easier to use. No complex programs or controls to learn or restrict your sectioning operation. **It's straight forward design allows the operator to concentrate on sectioning samples, not operating the machine.**

Coolant is stored below and applied to sample by rotating the blade. Saw table has a **large working area** measuring **6" x 10"** has no inhibiting lip. The saw housing is made from unbreakable cross-linked polyethylene and the housing is guaranteed for life. The saw has powerful 1/4 HP motor, running at ***variable speed of 400 to 3,400 RPM. Allowing the user to adjust RPM's to better fit sample/material being cut***. Motor is designed to insure that selected speed remains constant at any load. Sectioning is done in closed environment by utilizing Plexiglas Cover. Gravity Weight Feed allows samples to be sectioned unattended (without operator presence). ***Most Samples / Materials can be sectioned in seconds or few minutes, with no material deformation, & preserving sample/material True Micro Structure***. **Made in U.S.A.**

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BEOFORE PUGGING IN, PLEASE READ INSTRUCTIONS THOGOUGHLY. The machine is potentially dangerous if improperly used. Please be sure to operate according to instructions and with the proper guards where applicable.

CAUTION

1. Never operate the saw without goggles or other safety eye equipment. Be sure that anyone who is observing nearby has adequate eye protection as well.
2. Never try and change the direction of a cut in progress. This Saw is designed to make straight cuts only. Ignoring this or attempting to turn corners will result in damage t the diamond blade and possible personal injury.
3. Always unplug machine when doing maintenance or when not in use.
4. Never use the lade dry – it is designed for use with water, water soluble coolant, oil, and other types of coolants. The saw will be ruined immediately if used dry.

OPERATION INSTRUCTIONS

1. carefully unpack the saw from box, thoroughly checking all packing material to make sure no accessories or small parts are inadvertently discarded. Inspect the machine to make sure that no damage has been incurred in shipping. Should the machine arrive in a damaged condition and damage to the carton indicates it occurred in transit, IMMEDIATELY contact the delivering shipping company and fill out any necessary forms for reimbursement. Although our quality control inspection makes it highly unlikely, should there be any missing parts or defects in material or workmanship, contact UKAM Industrial Superhard Tools for repair or replacement.
2. Remove the black saw table by lifting it up in front, pulling toward you. Use pliers to loosen bolt on end of arbor, turning in a counter clockwise direction. Remove bolt and flared washer. Place diamond blade on the end of arbor, making sure that it fits on the lip. Replace flared washer and bolt, screwing clockwise to secure blade. Do not over tighten. Bolt should be just a little more than finger tight.
3. Diamond blades require dressing. This means that the protective matrix around the diamond must be removed and reposed before the blade can cut effectively. Read the directions that come with the blade to see if this step is necessary. If so use a dressing stick and lay it on the table in front of the blade; cut through the stick several times. Doing so will remove the protective coating from the blade. Now it is ready to use.
4. Place the material to be cut on the saw table and line it up properly with diamond blade. Slide the material lightly into the blade until a groove forms; then firmly push the material slowly through the blade. Remember, the saw will only cut in a straight line. Don not attempt to cut curves. A diamond blades works best when material is pushed firmly against it. However, NEVER force a diamond blade.
5. Material to be cut should never exceed 2/3 size of the visible cutting area of blade. Do not attempt to cut materials not recommended for the diamond blade.
6. When working with several pieces of material, be sure to replenish coolant as need to prevent cutting dry.
7. As you near the end of the cut, reduce pressure on material. This will avoid a sudden break through and give a cleaner cut.

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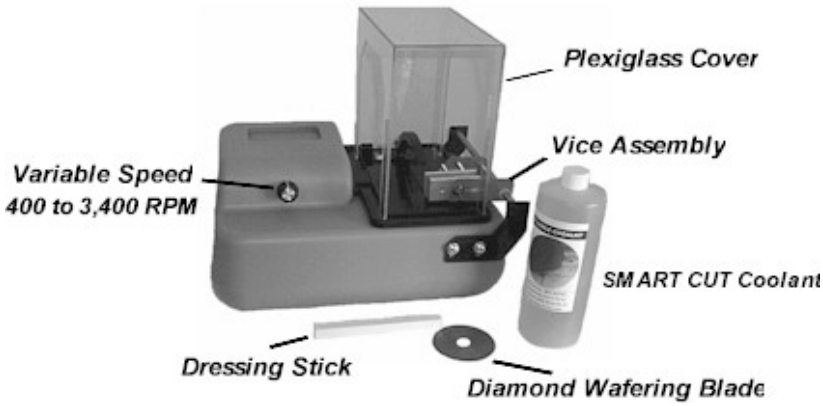
When work is completed, turn of switch, and unplug the saw. Drain coolant from sump, drying machine and blade with paper towels or and old rag. Briefly turn on saw to spin dry the blade thoroughly.Put on your safety goggles; turn on the power switch. Pour additional water of the blade until there is a fine mist and a small amount of splash around the blade.

CAUSTION: Do not over fill sump, as it will splash everywhere. The ***SMART CUT™*** 4002 Precision Diamond Saw is designed to be operated with coolant. NEVER operate the saw dry, this will run the blade within seconds.

For best sawing results, we recommend using SMART CUT™ Diamond Blades. Contact: UKAM Industrial Superhard Tools for the right diamond blade for your application. The diamond blade itself is the most important part/factor of your sawing operation.

SMART CUT™ 4002 Sectioning Saw Maintenance

- Always unplug machine when doing maintenance or when not in use.
- Make sure to dry saw and blade after each use. Doing so will prevent rust to blade.
- If saw is stored with coolant in the sump (not recommended) be sure to lower the coolant level so that is beneath the blade. Otherwise the blade may rust
- Saw arbor and shaft it fits on are made from different materials. Over time they may become galvanized and stick together making it impossible to remove the arbor. For this reason we recommend removing the arbor using an Allen wrench, turning clockwise every 2 months or so. Place a few drops of oil on the shaft, rubbing to coat shaft lightly. Replace the arbor using then allen wrench to tighten.
- **Make sure to not get any coolant down the shaft and into the motor. Doing so will cause the motor to burn out.**
- Do not pour used coolant down the drain as it can harden like cement, closing up the drain.
- Do not modify the machine from its intended use
- Always use safety face shield, goggles, or glasses to protect eyes
- Always disconnect electricity before attempting any maintenance or cleaning
- Never operate the machine unless properly instructed in its proper and safe use



OPERATING SUGGESTIONS & RECOMMENDATIONS

- Select the Right Blade for your Application
- Properly secure material – improper clamping my result in blade and material damage
- Check coolant levels and replace when low or excessively dirty
- Allow blade to reach its operating speed before beginning the cut
- A steady force will produce the best cuts and minimize blade wear as well as maintain material integrity (no burning or material deformation)

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Comes with:

1 unit – 3”, 4”, or 5” Diamond Wafering Blade. Sintered (metal bond) any grit size and diamond concentration for your specific application
1 unit – 1 quart of SMART CUT water soluable coolant or Mineral Oil
1 unit - Dressing Stick ½” x ½” x 6”. Grit Size: 120 or 220

Optional:

- Vice assembly
- Plexiglass Cover
- Gravity Weight Feed
- Micrometer

Sintered (Metal Bond) or CBN

3” x .010” x ½” or 5/8” ID
3” x .006” x ½” or 5/8” ID
3” x .005” x ½” or 5/8” ID
3” x .004” x ½” or 5/8” ID
4” x .020” x ½” or 5/8” ID
4” x .014” x ½” or 5/8” ID
4” x .010” x ½” or 5/8” ID
5” x .020” x ½” or 5/8” ID
5” x .014” x ½” or 5/8” ID
5” x .010” x ½” or 5/8” ID

Electroplated (Plated)

4” x .007” x ½” or 5/8” ID
4” x .012” x ½” or 5/8” ID

All wafering blades are available from stock in different diamond concentrations, grit sizes, and bond harnesses to fit your specific application. Blades can be used with plain water, water soluble coolant, or oil.

Vice Specifications/Material Capacity:

Width: 1.1430" (29.032mm) **Height:** 2.2075" (56.071mm) **Length:** 2.50" (63.5mm)

SMART CUT 4002 Vise Assembly is an adjustable guide that allows for accurate precision cuts.

Wing nuts are tightened to clamp the work piece securely in place. The carriage advances slowly to feed material evenly into the blade. Easily installed by bolting into place. Samples can be accurately positioned in vice.

Vise can be easily adjusted to accommodate a large variety of material sizes, thickness, shapes, and configurations.

SMART CUT 4002 vises to hold longer samples for applications such as slot cutting and cutting samples on angle.

Gravity Weight Feed

Allows samples/material to be sectioned unattended (without operator presence). Gravity weight feed propels material / sample firmly positioned in vice assembly into rotating blade. Weight can be adjusted depending on material diameter, hardness, & density. As well as users objectives for sectioning speed in correlation quality of cut, and surface finish.

***SMART CUT*™ Synthetic Water Soluble Coolant**

Stream of SMART CUT™ coolant added to deionized (DI) water reduces material thermal stress, edge damage, & internal cracking, assuring long-term integrity of material being cut. Since SMART CUT™ KOOL is a coolant and lubricant, both the diamond blade and material benefit.

- **Improve Sectioning Speed and Efficiency**
- **Increase Blade Life**
- **Improve Material Surface Finish**
- **Reduce Chipping**
- **Reduce Material Cracking**
- **Preserve Material True Micro**

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M **= Sintered (Metal Bond).** R **= Resin Bond.** H **= Hybrid Bond.** E **= Electroplated (Nickel Bond).** **MCBN = Metal Bond Cubic Boron Nitride.** RCBN **= Resin Bond Cubic Boron Nitride.** HCBN **= Hybrid Cubic Boron**

Acrylic Glass	E
Agate	M
Al-Ni-Co	RCBN
Alumina (fused)	M
Aramit Fibre Plastics	M
Barium Titanate	R/H
Boron Carbide	M
Brake Lining	E
Cemented Carbide	M/R

CERAMICS

Oxide ceramics, sintered	
Al2O3 (aluminium oxide)	M
Al2O3 (tubes)	R/H
Al2O3 (electronic resistors)	E/M
Al2O3 (seals)	M
Carbide Ceramics	R/H
TIC (titanium carbide)	M

NITRIDE CERAMICS

Si3N4 (HPSN) silicon nitride	R/H
Ceramic Tiles	M
Ceramics Unfired	E
Chrome Nickel (10% Cr, 90% Ni)	RCBN/HCBN
CRP (carbon reinforced plastic)	M
Epoxy Resin Boards	E
Epoxy Copper-Clad with circuits	E
Eternite (asbestos-free)	E/M
Formica (nameplates)	E
Germanium (semiconductor)	M
GGG (semiconductor)	E/R/H
Glass Optical	M
Glass Fibres (bundeled)	E/R
Glass Sheet	M
Glass Ceramics	M/R
Glass Hard Laminate (cast epoxy)	E
Glass Fibre Reinforced	E
Glass Laminates (safety/bullet proof glass)	M/H
Glass (quartz glass tubes)	R/H
Glass Wool	E
Glass (pyrostop)	M/H
Glass (thick optics)	M/H
Glass Technical	M
Glass Fibre Rod	E
Glass Hard Laminate	R/H
Granite	M
Graphite	E/M
GRP (window sections)	E
GRP (constructional sections)	M
GRP (internal thermoplastic ring)	E
Helopal Panels (plastic)	E
Hematite	M
HSS Punches	RCBN
HSS Hardened	RCBN
Insulators Ceramic	M
Lapis Lazuli	M

MAGNETIC MATERIALS

Ferrites Sintered	M/R
Ferrites Cast	MCBN
Rare Earth Magnetic Materials	R/H
Samarium Cobalt	M/R
Malachite	M
Marble	M/E
Melamine Resin	E
Metal Coated Ceramics	E/M
Moybdenum	RCBN/H
Mycalex (cast stone)	M/E
Ni Hard Rods	RCBN
Piezoceramics	M
Polycarbonate (glass reinforced)	E
Polystyrene Sheets	E
Printed Circuit Boards	E/M
PVC Hard	E/M
Quartz (fusable)	M/R
Quartz (synthetic)	M
Rhodochrosite	M
Rose Quartz	M
Sapphire	M/R/H
Sendust	E
Silicon (polycrystalline)	E
Silicon Carbide (pressed & crushed)	M
Silicon (monocrystalline)	M
Silicon (semiconductor)	M
Silicon Nitride	R/H
Silicon Carbide (ReSiC)	R/H
Steatite	M/R/MCBN
Stellite	M
Tiger's Eye	M
Titanium	M/R/H
Titanium Carbide	M
Titanium Zirconate	M
Topaz	M
Tungsten	M/R/E
Tungsten Wires	M
Uranium Dioxide	M
Uranium	M
Zirconium	M

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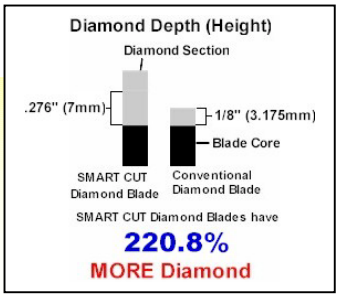
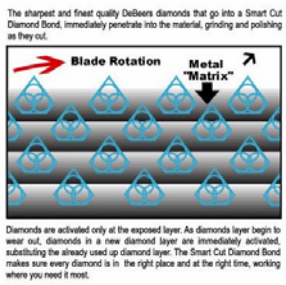
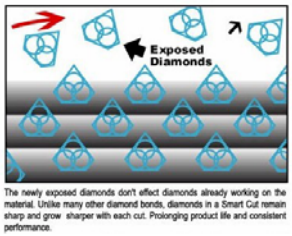


SMART CUT™ precision Diamond Wafering Blades are designed and specially selected to provide the maximum possible blade life for your desired cut quality, and speed.

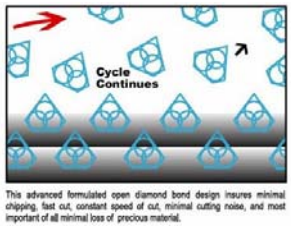
UKAM Industrial Superhard Tools is one of the leading manufacturers of high Precision Diamond Wafering Blades in the world. From 0.5" to 72" OD, starting .001" TH and up. With over 50 years of experience in manufacturing, research, and development. Following the belief .that there is always room for improvement. We continue to raise standards for the whole industry. In addition to manufacturing diamond wafering / sectioning blades for our own SMART CUT series Precision Diamond Saws. We manufacture many Diamond Wafering Blades used on other well know sectioning / wafering saws.



We recognize that the Diamond Wafering / Sectioning Blade by itself is perhaps the most important factor in your sectioning / precision diamond sawing operation. The diamonds impregnated inside the bond matrix of the wafering blade, are what actually participate in cutting action. No matter how precision or well made your wafering saw. You will not be able to obtain the material surface finish, and precision tolerances you need, if the blade you are using is not right for your application



UKAM Industrial Superhard Tools proprietary blade chemistry, precision manufacturing methods, modern quality control methods, allow us to control and regulate the dozens of variables that affect blade life, quality of cut, surface finish. Reducing and often eliminating additional steps often required after sectioning. All blades are manufactured to fit your specific material, application, and surface finish requirements. We will work with you to determine your needs, and develop the right bond formulation, concentration, and grit sizes.



UKAM Industrial Superhard Tools has one of the L**argest Inventory of Precision Diamond Wafering Blades in the U.S.** With over 4,000 diamond wafering blades in stock, available **in different sizes, thickness, arbor sizes, diamond concentrations, diamond mesh sizes, and bond hardness's**.

You are sure to find the <u>Right</u> Diamond Wafering Blade for your application in stock and ready for same day delivery. If you are not using these blades, you are paying too much.

SMART CUT™ technology.

Advanced technology that redefines the standard in cutting.

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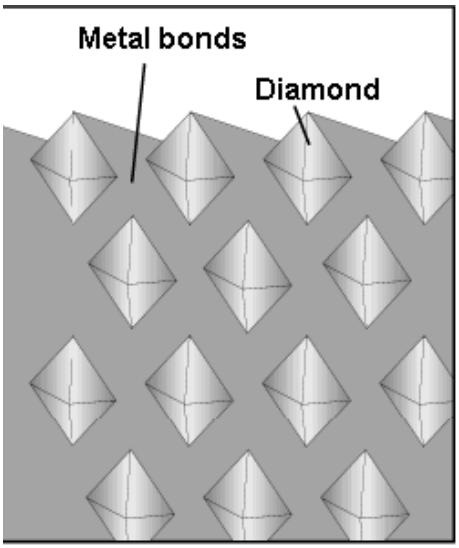
SELECTING RIGHT DIAMOND BLAE FOR YOUR APPLICATION

Selecting the right parameters for your Precision & Ultra Thin Diamond Blade can be a very time consuming, trial & error frustrating process. **The guide below has been designed to help you better understand the most important diamond blade variables, which will play a major role in performance, cutting speed, and surface finish of your Precision Diamond Blade**. Selecting the Right Diamond Blade for your specific Material / Application will also minimize the secondary operations that may be required afterwards such as lapping, grinding, & polishing. The following are some factors to consider when selecting the right diamond blade for your application.

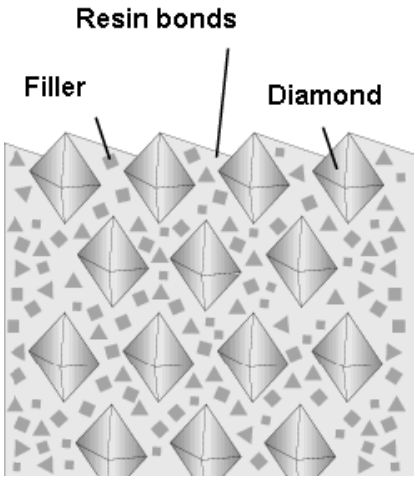
Understanding Diamond Bond Types & their Application



Sintered (Metal bonded) diamond blades diamonds sintered and multiple layers of diamonds impregnated inside the metal matrix. Diamonds are furnaces sintered in a matrix made of iron, cobalt, nickel, bronze, copper, tungsten, alloys of these powders or other metals in various combinations. Metal Bonded Diamond Tools are “impregnated” with diamonds. The compacted materials are then hot pressed or sintered to full density. Heating rate, applied pressure, sintering temperature and holding time, are all controlled according to the matrix composition.

This means that selected diamonds are mixed and sintered with specific metal alloys to achieve the best cutting performance possible on any materials such as sapphire, advanced ceramics, optics, glass, granite, tile and etc. The metal bond surrounding the diamonds must wear away to continuously keep re-exposing the diamonds for the diamond tool to continue cutting. **Sintered (metal bonded) diamond tools are recommended for machining hard materials from 45 to 75 on Rockwell Scale (5 to 9.5 on mohs scale of hardness)**. It is more wear resistant and holds diamond well in place, usually producing the highest yield/cutting ratio.

As a general rule of thumb, ***Metal Bond (sintered) diamond blades longer than other diamond bond blades such as resin bond and electroplated (nickel bond) blades.*** They wear evenly, and are known for their long life & consistency. **Sintered (metal bonded) diamond blades** are the latest technology available in Diamond Blades. And represent the best value and performance per cut. Metal bond matrix does not protrude diamonds very high and hence usually requires lower cutting speeds than electroplated (nickel bond) and resin bond blades.



Resin Bond Diamond Blades last less than Sintered (Metal Bond) diamond blades, but more than electroplated (nickel bond) diamond blades. Resin Bond is the softest of all the bonds, frequently used in applications that require a smooth surface finish and minimum amount of chipping. Made from a tough polymer formed to hold the diamond particles in the bond. A resin bond is really tar in a solid form. A resin bond must remain very fragile in order to expose new diamonds. For this reason, strong and high quality diamonds cannot be used in a resin bond. High quality diamonds are harder than a resin bond matrix, and would soon disintegrate the bond that keeps them in place. The diamonds that are used in a resin bond are poor to medium quality. Most of them prematurely disintegrate or fall out of the bond, before they have a chance of being used. his brings about the need for frequent blade dressing, causing the cut to loose its roundness or form. Another disadvantage of Resin bond is its high wear rate, lack

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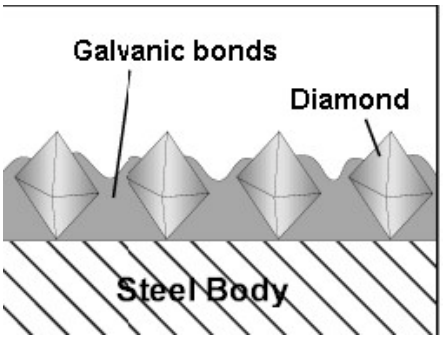
Resin bond can cut hard & brittle materials fast, but will provide much shorter life. Thinnest blades that can be produced in resin bond is .004". A more durable bond is sintered (metal bond).



Electroplated Diamond Blades have a high diamond concentration and give a freer, faster cutting action with minimum heat generation. Diamonds stay on the surface of the cut allowing for fast material removal. Electroplated Diamond Blades last less than metal bond, resin bond, hybrid bond blades and are the least expensive diamond blades available. Perfect for smaller jobs and beginning cutting operations. Just about the only type of diamond blade that may be used dry (without coolant) in a few applications, excellent for cutting very soft, ductile, & gummy materials. Electroplated diamond blades are frequently used for dry cutting (when coolant cannot be used). Electroplated blades a particularly **well suited for cutting thermosetting plastics, GRP, pre-sintered and pre-fired (green) materials, electro carbons, graphite, soft ferrites, farinaceous products, deep frozen fish, bones, pc boards, and etc.**

Diamond / Abrasive Selection

Diamond is universally recognized as the hardest substance known to man. ***Diamond is recommended for machining hard & brittle materials, optics, semiconductor packages, advanced materials, composites, ferrous & non ferrous metallic materials from 40 on Rockwell scale and up***. Diamond crystals can be synthetically grown in a wide variety of qualities, shapes and sizes. Diamond is grown with smooth crystal faces in a cubo-octahedral shape and the color is typically from light yellow to medium yellow-green. Diamond is also grown to a specific toughness, which generally increases as the crystal size decreases.

Synthetic (Men Made) Diamonds - Most frequently used for most diamond blade manufacturing including sintered (metal bond), resin bond, electroplating (nickel bond). Synthetic diamond is more consistent in particle shape, hardness, and density. Synthetic diamond has replaced natural diamond in most applications because of this ability to tailor-make the diamond for the specific application.

Cubic Boron Nitride (CBN) - often used for machining materials with high metallic content.

The ability of a diamond to withstand an impact load is typically referred to as diamond impact strength. **Other diamond-related factors, such as crystal shape, size, inclusions and the distribution of these crystal properties, play a role in the impact strength as well**. Impact strength can be measured and is commonly referred to as Toughness Index (TI). In addition, crystals are also subjected to very high temperatures during manufacturing and sometimes during the cutting process. Thermal Toughness Index (TTI) is the measure of the ability of a diamond crystal to withstand thermal cycling. Subjecting the diamond crystals to high temperature, allowing them to return to room temperature, and then measuring the change in toughness makes this measurement useful to a diamond tool manufacturer.

The manufacturer must select the right diamond based on previous experience or input from the operator in the field. This decision is based, in part, on the tool's design, bond properties, material to be cut and machine power. These factors must be balanced by the selection of diamond grade and concentration that will provide the operator with optimum performance at a suitable cost.

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DIAMOND BLADE VARIABLES

Bond Hardness – Ability of the bond matrix to hold diamonds. As the hardness of the bond is increased, its diamond retention capabilities increase as well. However the trade off is slower cutting speed. Life of the diamond blade is usually increased with hardness of its bond matrix. Bonds are designated on their scale of hardness from Soft, Medium, and Hard. There are dozens of variations and classification schemes based on bond degree of hardness or softness. Using diamond blades with optimum bond hardness for your application is important to successful precision diamond sawing operation. Bond matrix that is too soft for the material being cut will release diamond particles faster than needed, resulting in faster wear and shorter diamond blade life. On other hand bond matrix that is too hard will result in much slower cutting speeds and require constant dressing to expose the next diamond layer. As rule of thumb, harder materials such as sapphire and alumina generally require a softer bond. Whereas softer and more brittle materials require a harder bond.

Diamond Grit Size (Mesh Size) – grit size (mesh size) is generally selected depending on the speed you wish to operate the cut and surface finish of your material. According to U.S. Standards, mesh designates the approximate number of sieve meshes per inch. High Mesh Sizes mean fine grits, and low numbers indicate coarse grits. ***Diamond Mesh Size plays a major role in determining the surface finish quality, smoothness, level of chipping you will obtain, and material microstructure damage you will obtain***. Finer mesh size diamonds such as 220 and 320 grit are much smaller in size than coarser diamond particles. And will give you a very smooth surface finish, with minimal amount of chipping on edges. These mesh sizes are usually used for fine cutting of a full rage of materials such as: LiNbO3, YVO4, GaAs, and optical materials. Courser diamond particles such as 80 and 100 grit are much larger in diameter and are frequently used fast cutting / material removal on more harder materials such as silicon carbide, zirconia, Al2O3, stainless steels, and other advanced ceramics and high metallic content materials. Which do not require a very fine surface finish. ***A full range of diamond Mesh Sizes is utilized for precision diamond sawing operations ranging from as coarse as 60 mesh to as fine as 3 microns (5,000 mesh).***

The diamond mesh size in a cutting tool also directly relates to the number of crystals per carat and the free cutting capability of the diamond tool. The smaller the mesh size, the larger the diamond crystals, while larger mesh size means smaller diamond. A 30/40 Mesh blocky diamond has about 660 crystals per carat, while a 40/50 Mesh diamond will have 1,700 crystals per carat. Specifying the proper mesh size is the job of the diamond wheel manufacturer. Producing the right number of cutting points can maximize the life of the tool and minimize the machine power requirements. As an example, a diamond tool manufacturer may choose to use a finer mesh size to increase the number of cutting crystals on a low concentration tool, which improves tool life and power requirements.

Diamond Mesh size does have considerable effect on cutting speed. Coarse Diamonds are larger than finer diamonds and will remove more material than finer diamond particles. This means that coarse diamond wheels are more aggressive for material removal than the finer diamond wheels and will cut faster. However, the tradeoff is increase in material micro damage. If you are cutting fragile, more delicate materials then finer mesh size diamond blades are recommended. Diamond mesh size (grit size) should provide maximum removal rate at minimal acceptable finish. Often the desired finish cannot be achieved in a single step/operation. Lapping or polishing may be necessary to produce desired surface finish, as a secondary step in your diamond sawing operation / process.

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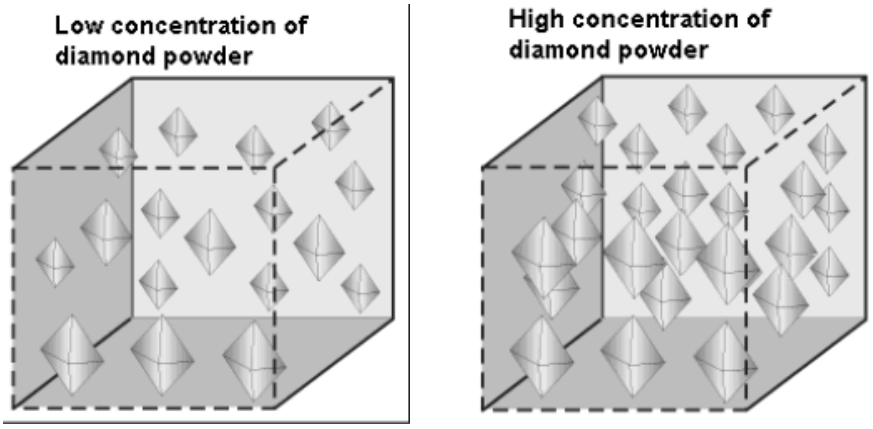
Diamond Concentration - The proportion, and distribution of diamond abrasive particles, also known as concentration. has an effect on overall cutting performance and price of precision diamond blades. Diamond concentration, commonly referred to as CON, is a measure of the amount of diamond contained in a diamond section of drill based upon volume. Diamond concentration is usually defined as: Concentration 100 = 4.4 ct per cm layer volume (mesh size + bond). Based on this definition a concentration of 100 means that the diamond proportion is 25% by volume of diamond layer, assuming at diamond density is 3.52 g/cm3 and 1 ct = 0.2g. Nominal diamond concentration in precision diamond blades range from 0.5 ct/cm3 to 6 ct/cm3. This means diamond concentrations are available from 8 to 135). Selecting the Right Diamond Concentration can be critical in optimizing your Precision Diamond Sawing Operation. Selecting Optimum Diamond Concentration for your application will depend on a large number of factors, such as:

- **Material Being Cut**
- **Bond Type and Hardness**
- **Diamond Mesh Size**
- **Cutting Speeds**
- **Coolants being used**



Diamond Concentration will play a major role in determining the life and cutting speed of your High Precision Diamond Blade. Higher diamond concentration is recommended and usually used for cutting softer and more abrasive types of materials. However, the trade off is significantly slower cutting speed. Low diamond concentration is recommended and widely used for cutting ultra hard and brittle materials. Diamond Concentration is usually determined by the the slowest cutting speed that is acceptable for a specific application. ***Optimum performance can be achieved when the diamond tool manufacturer utilizes their experience and analytical capabilities to balance diamond concentration and other factors to achieve optimum performance for the tool operator***. UKAM Industrial Superhard Tools has the experience & applications laboratory to help you select all the right diamond blade variables for your unique application.

Diamond Concentration & Cutting Performance

Today, most Production and R & D facilities use low concentration diamond blades for cutting ceramics, glasses, silicon, carbides, sapphire, and other related semiconductor and optical materials. And use high concentration diamond blades on metals such as stainless steel, aluminum, titanium, pc boards. A new technological breakthrough called ***SMART CUT***™ technology, is making fundamental changes in these beliefs and setting new benchmarks on how diamond blade performance is measured. SMART CUT technology allows the orientation of diamonds inside the metal matrix, so that every diamond is better able to participate in cutting action, By orienting diamonds, ***SMART CUT***™ technology makes diamond concentration only a minor factor in the overall precision diamond equation. Studies and extensive testing shows that diamond concentration in diamond blades manufactured utilizing ***SMART CUT***™ technology plays a no major role in determining overall diamond blade performance.

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Diamond Blades & Cutting Speeds

Ultra Thin & High Precison Diamond Blades can be used either at low or high speeds. There are advantages and disadvantages of each process. Diamond may break (fracture) at very high speeds, and fall out at very slow speeds. An optimum surface speed / RPM's must be selected to balance out the two disadvantages. Diamond Blade life will usually increase at slower cutting speeds. However the increase in labor costs, utilities costs, depreciation of equipment and other overhead expenses. Will usually offset the saving of diamond blade life and other consumables. **Cutting Speed & Surface Finish Quality is often the most important consideration when selecting the right diamond blade for your application**. **The operator mush choose a balance between life of the blades and their cutting rate.** Diamond has a higher impact strength than the material being machined. During the sawing operation, the diamond ruptures the material by impact. Each diamond is able to transfer the electrical power from your cutting machine, into momentum that breaks the material on nano / micro level.

By increasing power on your saw, your diamond blade RPM's and surface speed will increase as well. Hence, each diamond will chip off a smaller amount of material, reducing its impact force on material being machined. And reducing cutting resistance. In theory, by increasing surface speed / RPM's, each diamond should receive a smaller impact force. However, because impact is supported by a smaller volume, the impact force with this low volume is actually increased. There is a higher probability that the diamond particles will break or shatter. Hence, cutting materials at very low surface speeds, creates a large impact force between diamond and material being machined. Although the diamond may not break, the risk that the diamond will be pulled out of diamond blade and causing premature failure of the blade increases.

Understanding Material Hardness & its affect on Diamond Blade Performance

Material Hardness has several meanings. Most common definition for material hardness refers to its ability to resist deformation. Scientifically hardness is defined by energy density (energy per unit volume) required to create strain in material. While there are many ways, scales, and classification schemes to measure material hardness. In this article we will address the most simple explanation.

Mohs scale of Abrasion Hardness is the most simple and well known material hardness measurement and classification methods. In this scale material hardness is measured by scratch test of rubbing each material against another. All material harnesses are arranged in 10 ranks. Each rank is calibrated by a standard mineral. Below find these minerals in their rank of hardness from softest to hardest.

Diamond is the hardest material known to mankind. It can penetrate into any material. Brittle or Soft materials such as granite, advanced ceramics, and copper can be cut by diamond, without diamond particles being broken or exhibiting large pull out. However, when cutting very tough and dense materials such as cemented/tungsten carbide, the contact pressure of each diamond particle must be increased in order to allow diamond to penetrate being cut. ***The Hardness, Density, & Brittleness of the material being cut will determine whether the diamonds inside the diamond bond matrix need to be blocky and tough enough in order to break (rupture) material by brutal force or if they should be friable & flexible to penetrate the material by sharp points.***

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Proposed Scale of Hardness for Industrial Materials

Material	Formula	Mohs Hardness	Knoop Hardness	Rank	Industrial Hardness
Graphite	C	1 -	12	3.6	3
Molybdenite	MoS2	1	17	4.1	4
Aluminum, annealed	Al	2 -	25	4.6	
Table Salt	NaCl	2	30	4.9	
Gypsum	CaSo4	2	32	5.0	5
Silver	Ag	2+	60	5.9	6
Mild Steel, annealed	Fe	2+	123	6.9	
Calcite	CaCO3	3	135	7.1	7
Copper	Cu	4	163	7.3	
Indium Antimonide	InSB	4+	220	7.8	8
Magnesia	MgO	5-	370	8.5	
Glass	Soda lime	6-	530	9.0	9
Tool Steel	Fe	6+	700	9.5	
Quartz	SiO2	7	820	9.7	
Chromium	Cr	7	935	9.9	
Zirconia	ZrO2	8-	1160	10.2	10
Cemented WC	WC-Co(8%)	8-	1200	10.2	
Beryllia	BeO	8-	1250	10.3	
Silicon	Se	8	1400	10.5	
Titanium nitride	TiN	9-	1800	10.8	
Corundum	Al203	9	2100	11	11
Silicon Nitride	Si3N4	9	2100	11	
Tungsten Carbide	WC	9+	2400	11.2	
Titanium Carbide	TiC	9+	2470	11.3	
Silicon Carbide	SiC	9+	2880	11.5	
Boron Carbide	B4C	9+	3000	11.6	
Sintered cBN	BN	10-	3200	11.6	
Cubic boron nitride	BN	10-	4800	12.2	12
Sintered diamond	C	10-	5000	12.3	
Diamond (Type IIa)	C	10	9000	13.1	13

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Before Using

Make sure that the arrow on wheel point in the same direction as shaft rotation. Best performance and life will result. Before performing any cutting operations, let the tool run for a few seconds without load. If blade wobbles, vibration or unusual noise occurs, stop the tool immediately. Inspect blade for damage or incorrect mounting.

Securing your material while cutting

It is extremely important that the part you are cutting is clamped down and hold securely in place. So material does not move, if material does move while cutting it may break the diamond section of your blade. A clamp should be used for this purpose. **Do not hold the part (material) with your hands**. Doing so is dangerous, and your material will chip.

Cutting Speeds

RPM's will vary depending on the OD (Outside Diameter) of the blade and material to be cut. To improve blade life and help reduce wreckage, it is important to run blades at the proper RPM's and keep the diamonds exposed through dressing. Most blades should be operated in the range of 3,150 to 5,000 surface feet per minute. For soft, abrasive materials, RPM should increase. For hard, dense materials, RPM should decrease.

Faster cutting may reduce your working time slightly. However, the major trade off is a significant increase in friction and blade heat up, considerably reducing blade life and increasing the risk of heat fractures and breakage.

Meaning if a diamond blade develops dark “burn” marks at the diamond section, the blade is being used is too fast or the amount of pressure is too great. Reduce cutting speed or adjust pressure accordingly. It is generally recommended that you use a blade as fast as it will cut freely.

Sawing with Coolant

Coolant should always be used to cool and lubricate the blade. Most frequent source for diamond blade damage is cutting without enough coolant. It has been found that **generous flow of coolant** increases diamond blade efficiency**,** improves surface finish and reduces heat build-up and material cracks and deformation associated with overheating. Water is most often used coolant, providing excellent performance at minimal cost. Coolant must be applied in the proper place or it will not cool the blade or material being worked on properly. Coolant should always be directed so that the full flow is at the point of contact between blade and material, facing the same direction as rotation of the blade. The **amount of coolant used should increase with the hardness of the material being cut**. If you see sparks, there is insufficient coolant reaching the cutting zone or its simply ineffective.

Never run a diamond blade dry. Severe damage will result. Coolants do 3 things:

a.) cool blade and material being cut

b.) clean out abrasive particles formed while cutting

c.) provide lubrication to keep cutting edge clean

When cutting in harder materials such as granite, agate, quartz, porcelain, or very hard materials like sapphire and alumina, it is important to have lots of coolant.

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Determine the type of coolant you are planning to use. If you are planning to use water as a coolant, check with the blade manufacturer on what type of water recommended for your blade. City water with 90 psi or running water is usually used for cutting. For some applications, you may want to use an additive with your coolant. If you decide to go this route, you will need a circulating system and the right ratio between your additive and coolant.

UKAM Industrial Superhard Tools diamond wheels are designed to give you a straight cut in plain water. Although better performance and longer life in some cases may be obtained by using a **water soluble coolant**.

Diamond Blade Dressing & Truing

Feed material slowly into blade so the blade does not lead off. Excessive pressure can cause your wheel to bend or dish. Feed rate should never be so great that blade slows down. A diamond blade may occasionally require dressing with a **dressing stick** made specifically for this purpose. Use coolant for this procedure. The ***SMART CUT™*** Diamond Bond is designed to minimize this procedure. By using enough coolant and following suggested procedures you can rest assured this will require a minimum amount of time as compared to most blades.

Most Diamond Blades can be **dressed** (retrued) several times. Usually the wear on the diamond blade depth takes place on the Blade core and diamond section. Dressing causes diamonds to be pulled out from the blade diamond section (diamond part). For this reason, great care should be taken to reduce this effect. We suggest rexposing the diamond section with a Al203 (alumina oxide) stick after retrueing. This is a very simple operation: just cut into the dressing stick many times.

Applying Pressure to a Blade

When using diamond blades, it is very important to apply light to medium pressure. Gradually feeding blade it into material, until it begins to cut at its own speed.

Increasing pressure on the blade will do little towards reducing the time it takes you to complete a job. But will cause your blade to overload and overheat. This causes not only blade overheat (burn up), but it also heats up the material being cut, causing unwanted material cracks and deformation. If you can see dark “burn” marks around the diamond section, the cutting speed you are using is too fast or you are applying too much pressure.

When cutting completely through a piece of material and the cut is near completion, reduce pressure on your blade considerably. Doing so will reduce and minimize back and front side chipping. **Never force a diamond blade.**

Balancing Cutting Speed, Pressure and Coolant

Cutting speeds are affected by the hardness and abrasiveness of the material, age and condition of equipment, pressure and coolant. Experience with a specific material and applications allows the operator to develop the right cutting process for their particular application, and taking into account all of the factors discussed above. New users, who are just beginning to use diamond blades, are better using **thicker kerf blades**, applying lower speeds, lower pressure, and a large amount of coolant. Until they are able to build their experience using a specific diamond blade, set up, and application. Doing so will minimize the risk of diamond blade wreckage and material damage.

Cutting Depth

Most frequent source of diamond blade damage is attempting to cut too large piece of material. Maximum material size should not be more than 3/8" blade diameter.

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Thin Kerf / Ultra Thin Diamond Blades

Thin Kerf / Ultra thin blades Are used for to obtain more precision tolerances, faster cutting speed, and minimize loss of valuable material. Thinner blades provide less resistance against and impact against material, and can thus be operated at significantly more higher speeds. Including ultra hard & expensive materials minimum loss of material counts the most. Thinner blades will provide a smoother surface finish, faster cutting, greater cutting accuracy, minimize material loss and deformation.

Diamond Blade Maintenance

Proper Diamond Blade maintenance is very important for optimum cutting performance. Maintaining the diamond cutting edge shape, and rigidity is important to prevent the blade from loosing its sharpness and roundness.

When to replace a Diamond Blade

Diamond Blades that are:

a.) Dished b.) Bent c.) Not running true

should be replaced. If your diamond blade has a tendency to pull to one side, making uneven cuts. Reverse the blade, and try cutting again. If you still have the same problem, it could be your vise alignment. If after reversing the blade still cuts to opposite side. It may be bent or dished. Should this be the case, the blade must be repaired or replaced before further use. ***Never continue cutting with a damaged Diamond Blade.***

Do's

1. Always inspect flanges for burrs, warpage, cleanliness and flatness.

2. Check blades carefully before each use for proper alignment and possible defects.

3. Maintain a firm grip on blade during cutting operation

4. Keep bystanders and/or animals out of working area.

5. Make sure all Diamond Blade users comply with safety regulations. For use, see safety codes USA-ANSIB71 and OSHA regulations. Canada - CSA.

Don't

1. Do not alter (change) blade inside diameter (ID). Doing so will create unbalanced blade rotation and result in blade wobbling, pounding, or cracking witch could be hazardous.

2. Do not stand in line with blade and stream of hot particles.

3. Do not force a Diamond Blade. Most diamond blades are designed for straight line cutting only. Cutting curves can cause stress cracks or fragmentation of the blade. Resulting in possible injury to people in vicinity.

4. Do not use side pressure or grind with side of the blade.

WARNING:

Diamond Blades improperly used are dangerous. Comply with American National Standards institute Safety Code B71 and Occupational Safety and Health Act Covering SPEED - SAFETY - GUARDS - FLANGES - MOUNTING PROCEDURES - GENERAL INSPECTION - GENERAL MACHINE CONDITIONS.

WARNING:

Sawing generates dust. Excessive ariborne particles may cause irritation to eyes, skin and respiratory tract. To avoid breathing impairment always employ dust controals and protection sutable to the material being drilled. In accordance with OSHA (29 CFR 1910, 1200).

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Diamond Blade / Sawing Problem Solving / Trouble Shooting

Successful diamond sawing is both an art & science. Requiring the proper understanding of how to use speeds and feed rates, coolants, flanges, & material holding fixtures to maximize cutting efficiency, diamond blade and cut quality. While this understanding is best gained through experience, even new diamond blade users can quickly become proficient by learning and applying some basic principles of diamond sawing.

DIAMOND BLADE LIFE & PERFORMANCE

Material Hardness + Density + Cutting Depth + Material Shape/Geometry + RPM's + Feed Rate + Coolant Used + Cutting Equipment Type/Condition + Flange Size/Exposure + Material Holding Method + Operator Experience

= *DIAMOND BLADE LIFE & OVERALL PERFORMANCE*

Diamond Blade Life & Overall Performance will vary with material hardness, density, thickness, & cutting depth. Few other factors that play a role in diamond blade life & performance include: RPM's (cutting speed), Feed Rate, Geometry (shape) of Material, Coolant being Used, Coolant feed rate and Direction. Cutting Equipment, Material Clamping Method & experience of operator. While there is now way of accurately predicting Life of your diamond blade. It can be optimized by following **Principals of Proper Diamond Blade / Tool Usage**. There may also be some experimenting, as well as trial & error involved in the part of the end user. Highly experienced diamond blade users may find some variations in diamond blade life or performance even when working on same material & application. While this phenomena is not too common, it does occur. The machining environment around us is constantly changing. A slight change or variation in any variable can have significant impact on your diamond sawing results. Material being cut can vary in composition or density even when coming from same manufacturer or source. Slight change in coolant feed rate, coolant direction, RPM's, even the way the material is held in place can make the difference. Frequently the cause of the problem may not be obvious and may take as much as several failed attempts to surface.

When encountering problems or variation in diamond blade performance. ***Few stop to think about or carefully examine their cutting process***. Many users immediately suspect quality of the diamond blade and are quick in labeling the drill "Defective" or "Poor Quality". This is very rarely the case. Usually in over 90% of these cases the diamond blade itself was not at fault. Most Respectable & Experienced Diamond Blade Manufactures have rigid quality control and inspection processes set in place. Controlling everything from raw material input, output, to final inspection. As well as field test blades randomly. **What a number of diamond blade users don't realize the technical aspects & delicate nature of diamond sawing/machining process**. What is important to understand is that ***almost all diamond blade users, regardless of experience or technical background will make some type of an unintended operator error while at some point in their career***. With this in mind, UKAM Industrial Superhard Tools has assembled a list of most common diamond blade operator errors made by users in most industries & applications. **Looking through this guide will help you RESOLVE MOST COMMON DIFFICULTIES you may have in using your diamond blades, as well as AVOID MOST COMMON PROBLEMS in the first place.** **http://www.ukam.com/blade_trouble_shooting.htm**