**Quality Matters Newsletter**

# Diamond Wafer Cutting

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by Donald Zipperian, Ph.D.

## Diamond Wafer Cutting Applications

Diamond wafer cutting is a metallographic specimen preparation technique which has a very wide range of applications, including: cutting of delicate microelectronic components, biomedical devices, composites, engineering ceramics and petrographic specimens.

Most common metallographic diamond wafernig saws have micrometer control for producing very precise thin sections. Proper cutting parameters are dictated by the specimen hardness and toughness (see Guidelines Table).

In addition to properly setting the precision wafering saws cutting speed and applied load, the correct choice of the diamond wafer blade is critical. The most important characteristics or features of the diamond blade include: diamond concentration, diamond size, diamond bond and blade conditioning.

Continuous diamond wafering blades.

| Material | Characteristic | Speed (rpm) | Load (grams) | Blade (grit/conc.) |
|---|---|---|---|---|
| Silicon substrate | soft/brittle | <300 | <100 | Fine/low |
| Gallium arsenide | soft/brittle | <200 | <100 | Fine/low |
| Boron composites | very brittle | 500 | 250 | Fine/low |
| Ceramic fiber composites | very brittle | 1000 | 500 | Fine/low |
| Glasses | brittle | 1000 | 500 | Fine/low |
| Minerals | friable/brittle | >1500 | >500 | Fine/low |
| Alumina ceramic | hard/tough | >1500 | >500 | Medium / low |
| Zirconia (PSZ) | hard/tough | >3500 | >800 | Medium/low |
| Silicon nitride | hard/tough | >3500 | >800 | Medium/low |
| Metal matrix composites | | >3500 | >500 | Medium/high |
| General purpose | | variable | variable | Medium/high |

## Diamond Concentration

Almost all diamond wafering blades are classified as either high concentration or low concentration blades. As a general rule, low concentration blades are recommended for hard / brittle materials such as ceramics, whereas high concentration diamond blades are recommended for cutting more ductile materials such as metals and polymers. For hard / brittle materials low concentration blades allow for considerably higher cutting loads at the abrasive / sample interface. For hard / brittle materials such as ceramics the actual load on the diamond is increased by a factor of four. For example, boron carbide is a very hard and tough ceramic and cutting a 0.5-inch diameter sample at 3500 rpm and a 150 gram force results in very little cutting progress even after continuously cutting for three days. However by increasing the cutting force to 1000 grams the sample is cut in 30 seconds.

Conversely for metals and ductile materials, the number of cutting points is more important than cutting load, therefore for more ductile metals and polymers, high concentration blades are recommended.

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**Considerations for proper diamond wafer cutting**

- Diamond concentration
- Diamond particle size
- Diamond bonding material
- Cutting load
- Cutting speed
- Orientation of sample

PACE Technologies, Inc,
200 Larkin Dr. • Wheeling, IL 60090 USA
Phone: 888-PACE-654 • FAX: 847-753-9936
PACE@metallographic.com • www.metallographic.com

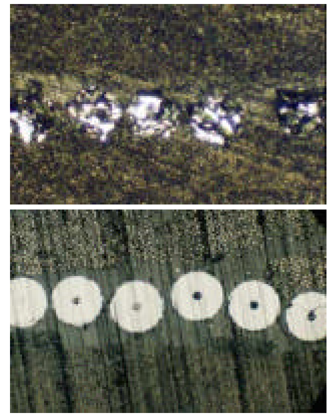
## Diamond Size

When sectioning very brittle materials such as silicon, glass, and hard fiber composites, one of the most important parameters to minimizing chipping and fracturing is the particle size of the diamond. Most metallographic standard diamond wafering blades use an average diamond particle size of 240 grit or 63 microns. For the fine grit blades the average particle size is 600 grit or a 15 micron particle size.

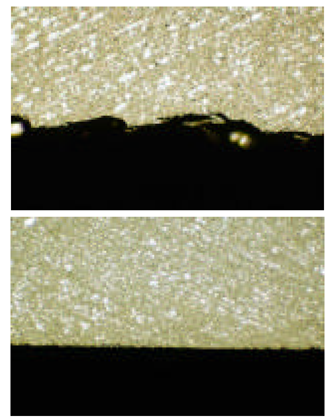
To the right is a comparison for the cross sectioning of a boron / graphite golf shaft composite. In this case a very hard boron fiber is added to the polymer / graphite composite material to strengthen and reduce twisting of the golf shaft tip. As can be seen the standard diamond wafering blade severely damages the boron fibers to the extent that the damage cannot be removed without causing other microstructural preparation artifacts such as edge rounding and relief around the hard fibers. On the other hand, the fine grit diamond produces a cut that is nearly damage free. The result is a much less demanding polishing operation for bringing out the true microstructure.

Another example of a fine grit diamond wafering blade application is in the sectioning of silicon wafer components where important microstuctural features may exist at the interface of the device. As shown, a standard grit sized diamond wafering blade severely damages the edge of the silicon specimen. Conversely, with the fine grit blade, the damage to the edge is minimal, thus significantly reducing the number of polishing steps and associated preparation induced artifacts associated with overpolishing.

Other applications include sectioning magnetic hard drive heads, minerals, fiber optics and glass.



Boron fiber in a graphite golf shaft
(a) upper image - standard grit blade
(b) lower image - finegrit blade



Silicon wafer cut with (a) upper image - standard grit blade (b) lower image - fine grit blade.

## Blade Dressing (conditioning)

Proper diamond wafering blade conditioning is important to maintain the performance and cutting efficiency of the blade.

To understand this importance, it must be understood that the diamond wafering blades are produced by mixing the diamond into a metal powder and then pressing this blend at high pressures. The metal powder is typically a copper or copper alloy material. The advantage to this powder is that it molds easily and adheres very well to the diamond. The drawback is that the metal can also smear over the diamond and blind the diamonds cutting edge.

To get around the blade smearing problem, dressing or conditioning the diamond blade is done periodically so as to remove this smeared material.

The most efficient method for dressing is to use a vitrified dressing stone at relatively low speeds and forces (150 rpm and <100 grams of force).

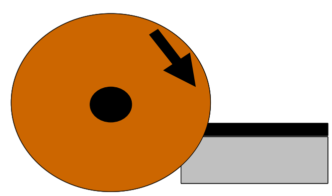
An example of the improved efficiency in cutting can be described in cutting a 0.5-inch diameter silicon nitride specimen repeatedly. For a new blade the cutting time is 30 seconds at 3500 rpm wheel speed for a 5-inch diameter blade and a 1000 gram load. The cutting time increases to 60 seconds for the second cut and then to 10 minutes for the third cut. Following a dressing step the cycle repeats itself with the first cut taking 30 seconds, followed by 1 minute and 10 minutes, respectively.

*"It's oftentimes easier to minimize cutting damage then to try to remove it later"*

## Specimen Orientation

There are a couple of general recommendations for mounting and orienting samples during sectioning. These include:

1. When sectioning coatings, maintain the coating in compression by orienting the sample so that the blade cuts into the coating and then the substrate.
2. To maximize cutting load on the sample, orient the sample so that the smallest cross section is being cut.
3. When possible hold both sides of the specimen to eliminate the cutting burr.
4. For brittle samples, pad the holder or chuck with a padded material to minimize chipping and edge damage.



Cut through the smallest cross section and orient sample so that coatings are kept in compression during sectioning.

PACE Technologies, Inc.
200 Larkin Dr. • Wheeling, IL 60090 USA
Phone: 888-PACE-654 • FAX: 847-753-9936
PACE@metallographic.com • www.metallographic.com

PACE Technologies
200 Larkin Dr.
Wheeling, IL 60090
www.metallographic.com

Phone: 847-520-4193
Fax: 847-520-4194
Email: Pace@metallographic.com

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For more information visit our web site at www.metallographic.com



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PACE Technologies offers metallographic testing consumables and equipment, including: abrasive blades, diamond wafering blades, compression and castable mounting compounds, grinding abrasives, polishing pads, diamond abrasives, final polishing alumina and colloidal silica abrasives.

As leaders in the field, we seek to provide technical information and innovations to the metallographer. Our Arizona research facility focuses primarily on the development of new products and processes for both the metallographic and industrial precision surface finishing markets.

Our web page offers the most complete metallographic web site for specimen preparation procedures and specimen preparation training, as well as links to other useful web sites. We have also just completed a technical and etchant database. Featuring thousands for etchants, this easy-to use database is the most comprehensive etchant database available on CD.

At PACE Technologies, our goal is customer satisfaction. We offer user-friendly technical and ordering information, instant communications and transparent pricing. Our employees practice a "customer-first" philosophy every day and it is this customer dedication which has made PACE Technologies today's leader in the supply of precision polishing consumables and equipment.