Precision Wafer Sectioning

3.0 PRECISION WAFER SECTIONING

Precision wafer cutting is used for sectioning very delicate samples or for sectioning a sample to a very precise location. Precision wafering saws typically have micrometers for precise alignment and positioning of the sample and have variable loading and cutting speed control (see Figure 3-1).

Figure 3-1 PICO 150 Precision Wafering Saw.

3.1 WAFERING BLADE CHARACTERISTICS

In order to minimize cutting damage, precision wafer cutting most frequently uses diamond wafering blades, however for some materials the use of cubic boron nitride (CBN) is more efficient. In addition, optimal wafer cutting is accomplished by maximizing the abrasive concentration and abrasive size, as well as choosing the most appropriate cutting speed and load. Table I provides some general guidelines and parameters for precision sectioning a variety of materials.

The particle size of fine grit diamond blades is 10-20 microns, or approximately 600 grit. For medium grit diamond wafering blades, the particle size is 60-70 micron, or 220 grit. For these types of wafering blades, the abrasive is mixed with a metal binder and then pressed under high pressure (Figure 3-2). As will be discussed in the next section, periodic dressing/conditioning of the metal pressed blades is required for optimum cutting performance of the blade.

Figure 3-2 Metal pressed diamond and CBN wafering blades.

TABLE I. Precision Cutting Blade Specifications

In some cases, precision cutting requires a coarser grit wafering blade. Usually the coarsest standard blade uses 120 grit abrasive particles. For metallographic applications, coarse abrasives are mostly associated with electroplated blades (Figure 3-3a). The main characteristic of coarse electroplated blades is that the abrasive has a much higher, or rougher, profile. The advantage of this higher profile is that the blade does not “gum up” when cutting softer materials such as bone, plastics and rubbery types of materials.

Although less common, thin resin-rubber abrasive blades can be used for cutting on precision wafering saws (Figure 3-3b). For cutting with abrasive blades on precision wafer saws, set the speed of the saw to at least 1500 rpm. Note that abrasive blades create significantly more debris which requires changing out of the cutting fluid more frequently.

Figure 3-3 (a) Electroplated diamond wafering blade for cutting soft materials (left) and (b) alumina resin-rubber blade (right).

Perhaps the most important parameter for precision sectioning is the abrasive size. Similar to grinding and polishing, finer abrasives produce less damage. For extremely brittle materials, finer abrasives are required to minimize and manage the damage produced during sectioning. Sectioning with a fine abrasive wafering blade is often the only way that a specimen can be cut so that the final polished specimen represents the true microstructure. Examples include: silicon computer chips, gallium arsenide, brittle glasses, ceramic composites, and boron-graphite composites. Figures 3-4a and 3-4b compare the effects of cutting with a fine grit blade vs. a standard medium grit blade for sectioning a boron graphite golf shaft. As can be seen, the fine grit blade produces significantly less damage to boron fibers.

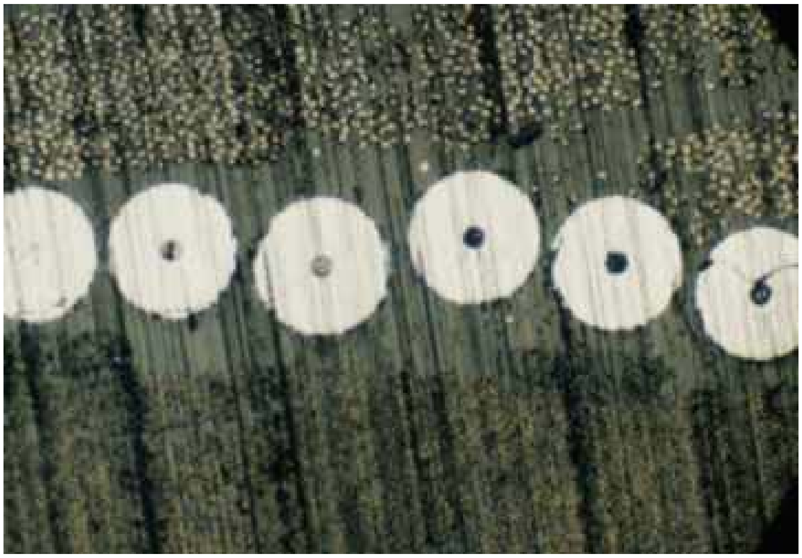

Figure 3-4a Fine grit diamond cut for boron graphite composite.

Figure 3-4b Medium grit diamond cut for boron graphite composite.

The second most important blade characteristic is the abrasive concentration because it directly affects the load which is applied during cutting. For example, brittle materials such as ceramics require higher effective loads to efficiently section; whereas, ductile materials such as metals require a higher abrasive concentration in order to have more cutting points. The result is that low concentration blades are recommended for sectioning hard brittle materials such as ceramics and high concentration blades are recommended for ductile materials containing a large fraction of metal or plastic.

TIP: Minimizing the amount of damage created during sectioning can significantly reduce the amount of time required for grinding and polishing.

The wafering blade bonding matrix can also significantly affect a blade's cutting performance. Metal pressed wafering blades require periodic dressing in order to maintain performance. A common misconception is that the cutting rates for these blades decrease because the diamond or abrasive is being "pulled out" of the blade. In reality, the metal bond is primarily smearing over the abrasive and "blinding" the cutting edge of the abrasive. With periodic dressing, using a ceramic abrasive encased in a relatively soft matrix (Figure 3-5), this smeared material is removed and the cutting rate restored. Figure 3-6 shows the effect of dressing a standard grit, low concentration diamond blade for cutting a very hard material such as silicon nitride. Without dressing the blade, the cut rate significantly decreases after each subsequent cut. After dressing the blade, the sample once again cuts like a new blade. Note it is highly recommended that a dressing fixture be used for conditioning or dressing the wafering blades in order to reduce the risk of breaking or chipping the wafering blades (Figure 3-7). Blade dressing is also accomplished at low speeds (<200 rpm) and at light loads (<100 grams).

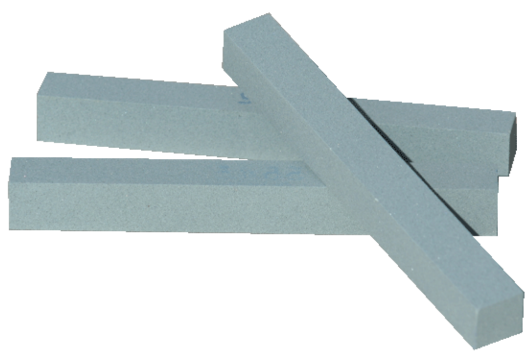

Figure 3-5 Alumina wafer blade dressing sticks.

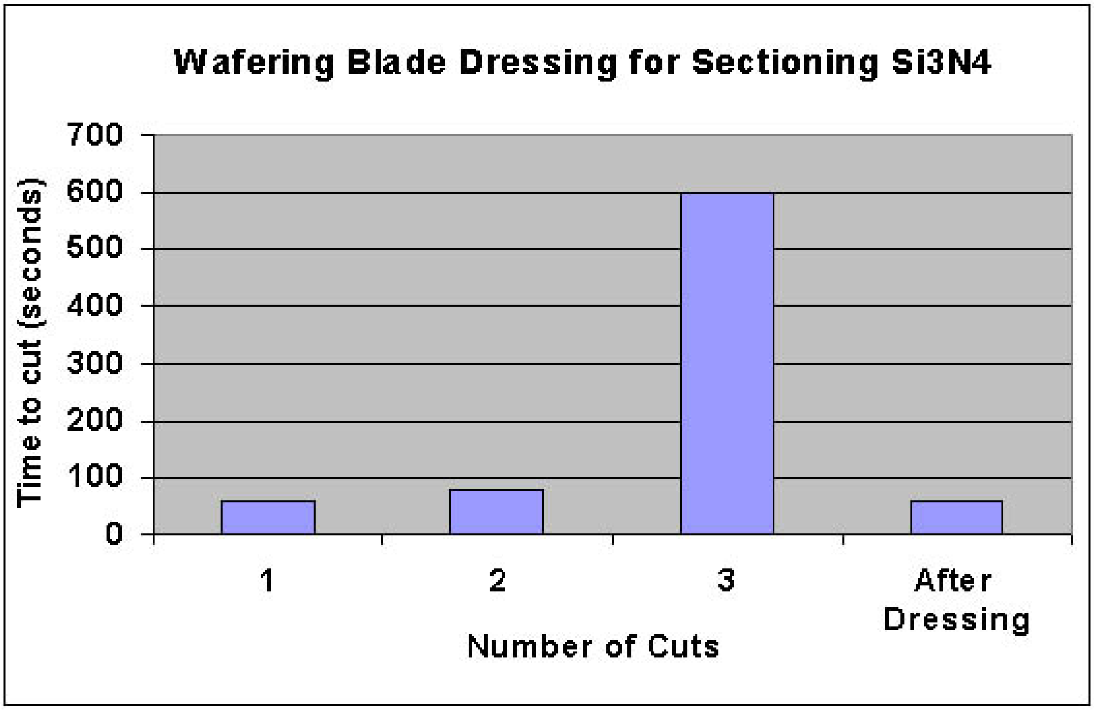

Figure 3-6 Cutting performance vs. wafering blade conditioning.

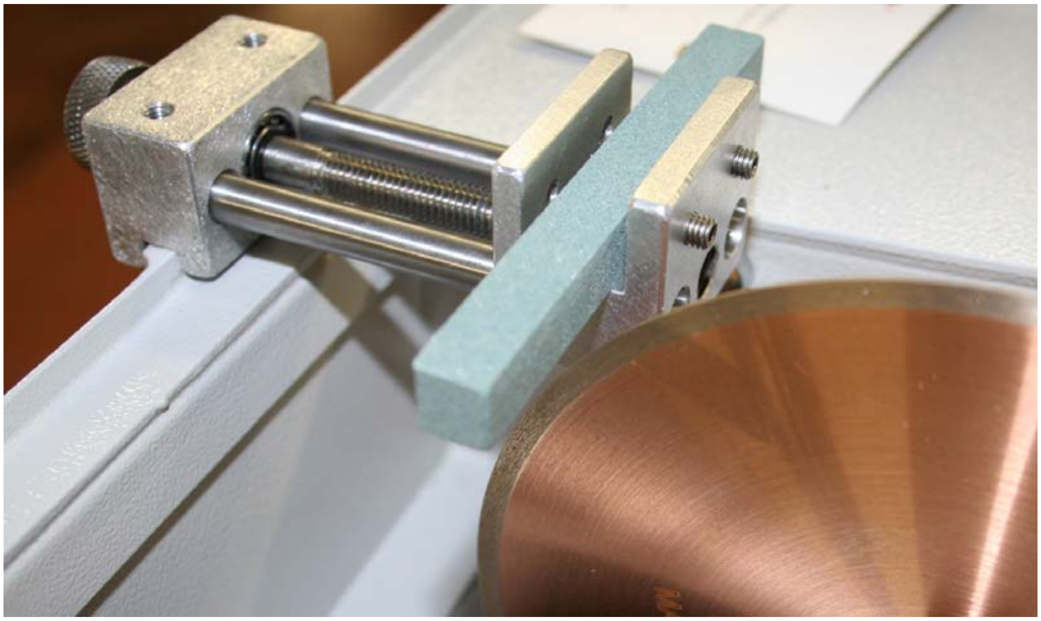

Figure 3-7 Proper dressing fixturing will minimize damage to the wafering blade.

Table II provides some recommended guidelines for sectioning a variety of materials ranging from very brittle to very hard and tough.

TABLE II. Guidelines for Wafering Cutting Various Materials

3.2 CUTTING PARAMETERS

Most wafer cutting is done at speeds between 50 rpm and 5000 rpm with loads varying from 10-1000 grams. Generally, harder specimens are cut at higher loads and speeds (e.g. ceramics and minerals) and more brittle specimens are cut at lower loads and speeds (e.g. electronic silicon substrates) (see Table IV). It is interesting to note that the cutting efficiency for sectioning hard/tough ceramics improves at higher speeds and higher loads. Figure 3.8 compares the resulting surface finish for sectioning partially stabilized zirconia at a low speed/low load (Figure 3-8a) vs. cutting at a higher load/higher speed (Figure 3-8b). As can be seen, partially stabilized zirconia has less fracturing and grain pull out after sectioning at higher speeds and loads. This observation may seem counter intuitive, however for sectioning hard/tough ceramics, high cutting speeds and loads result in producing a crack that propagates in the direction of the cut instead of laterally into the specimen.

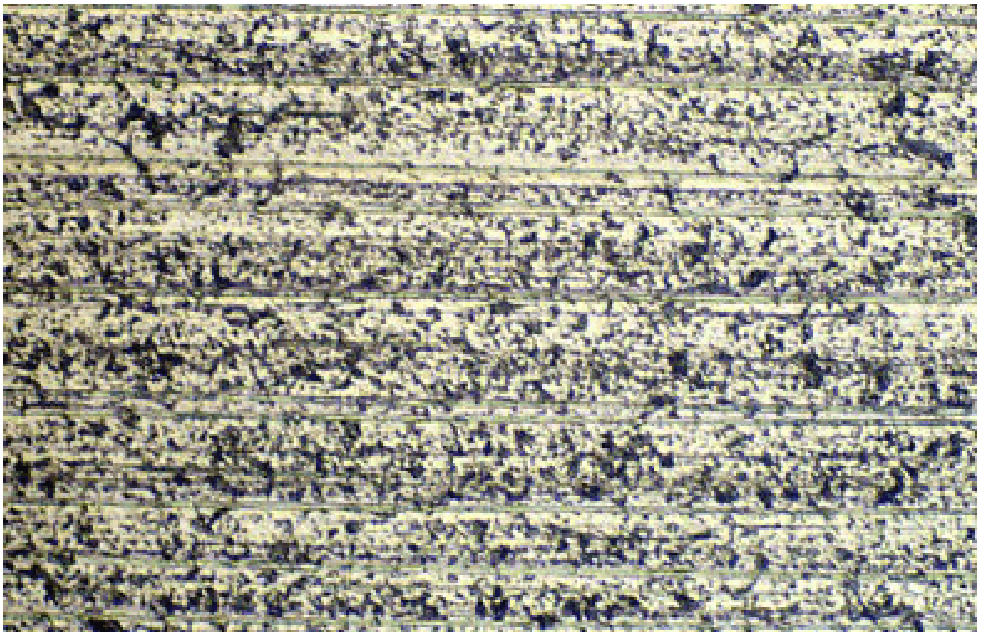

Figure 3-8a Partially stabilized zirconia sectioned at low speeds and low loads.

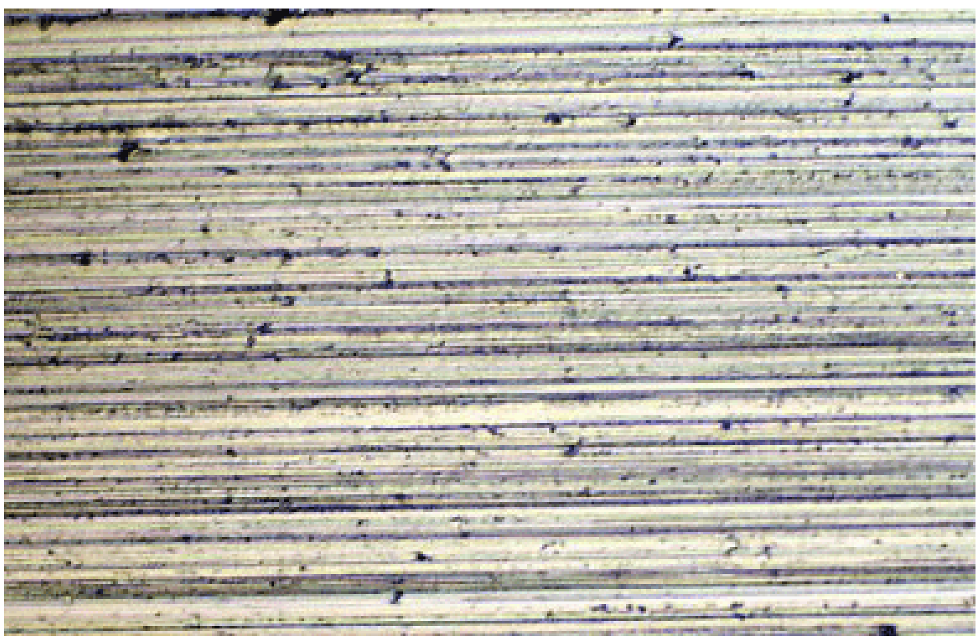

Figure 3-8b Partially stabilized zirconia sectioned at high speeds and high loads.

For wafer cutting it is recommended that a cutting fluid be used. The characteristics of a good cutting fluid include:

- Removes and suspends the cutting swarf
- Lubricates the blade and sample
- Reduces corrosion of the sample, blade and cutting machine parts

In general, cutting fluids are either water-based or oil-based (Figure 3-9). Water-based cutting fluids are the most common because they are easier to clean, however oil-based cutting fluids typically provide more lubrication.

Figure 3-9 Oil and water-based cutting fluids.

3.3 RECOMMENDED WAFER CUTTING PROCEDURES

- Prior to cutting the sample, condition or dress the wafering blade with the appropriate dressing stick.
- Clamp the specimen sufficiently so that the sample does not shift during cutting. If appropriate, clamp both sides of the specimen in order to eliminate the cutting burr which can form at the end of the cut.
- For brittle materials clamp the specimen with a rubber pad to absorb vibration from the cutting operation.
- Begin the cut with a lower force in order to set the blade cutting kerf.
- Orient the specimen so that it is cut through the smallest cross section.
- For samples with coatings, keep the coatings in compression by sectioning through the coating and into the substrate material.
- Use largest appropriate blade flanges to prevent the blade from wobbling or flexing during cutting.
- Reduce the force toward the end of the cut for brittle specimens
- Use the appropriate cutting fluid.

3.4 TROUBLESHOOTING GUIDELINES

TABLE III. Troubleshooting Guidelines for Wafering Cutting

3.5 PRECISON CUTTING CONSUMABLES

TABLE IV-1. 3-inch (76.2 mm) Wafering Blade, 1/2” (12.7 mm) Arbor

TABLE IV-2. 4-inch (102 mm) Wafering Blade, 1/2” (12.7 mm) Arbor

TABLE IV-3. 5-inch (127 mm) Wafering Blade, 1/2” (12.7 mm) Arbor

TABLE IV-4. 6-inch (153 mm) Wafering Blade, 1/2” (12.7 mm) Arbor

TABLE IV-5. 4-inch (178 mm) Wafering Blade, 1/2” (12.7 mm) Arbor

TABLE V. Cubric Boron Nitride (CBN) Wafering Blade, 1/2” (12.7 mm) Arbor

TABLE VI. Cuting Fluids for Precsion Saws

TABLE VII. Precsion Saws (miscellaneous)