Abrasive Sectioning

2.0 ABRASIVE SECTIONING

The first step in preparing a specimen for metallographic or microstructural analysis is to locate the area of interest. Sectioning or cutting is the most common technique for revealing the area of interest. Proper sectioning has the following characteristics:

DESIRABLE EFFECTS:
- Flat and cut close to the area of interest
- Minimal microstructural damage

Figure 2-1 Abrasive Cut-off Blades.

UNDESIRABLE EFFECTS:
- Smeared (plastically deformed) metal
- Heat affected zones (burning during cutting)
- Excessive subsurface damage (cracking in ceramics)
- Damage to secondary phases (e.g. graphite flakes, nodules or grain pull-out)

The goal of any cutting operation is to maximize the desirable effects, while minimizing the undesirable effects.

Sectioning can be categorized as either abrasive cutting and precision wafer cutting. abrasive cutting is generally used for metal specimens and is accomplished with silicon carbide or alumina abrasives in either a resin or resin-rubber bond. Proper blade selection is required to minimize burning and heat generation during cutting, which degrades both the specimen surface as well as the abrasive blades cutting efficiency. Wafer cutting is achieved with very thin precision blades. The most common wafering blades are rim-pressed abrasive blades, in which the abrasive is located along the edge or rim of the blade. Precision wafering blades most commonly use diamond abrasives, however cubic boron nitride (CBN) is also used for cutting samples that react to dull diamond (e.g. high carbon, heat treated steels cut more effectively with CBN as compared to diamond). Wafer cutting is especially useful for cutting electronic materials, ceramics and minerals, bone, composites and even some metallic materials.

2.1 ABRASIVE BLADE SELECTION GUIDELINES

Selecting the correct abrasive blade is dependent upon the design of the cut-off machine and, to a large extent, the operator preference. Abrasive blades are generally characterized by their abrasive type, bond type and hardness. Determining the correct blade is dependent upon the material or metal hardness and whether it is a ferrous or a nonferrous metal. In practice, it often comes down to odor and blade life. Resin/rubber blades smell more because the rubber will burn slightly during cutting, however resin/rubber blades do not wear as fast and therefore last longer. On the other hand, resin blades are more versatile and do not produce a burnt rubber odor, but they do break down faster. Resin blades also provide a modestly better cut because the cutting abrasive is continually renewed and thus produces a cleaner cut.

Also note that the traditional “older” technology for producing abrasive blades resulted in very specialized resin/rubber blades. Finding the proper resin/rubber hardness, abrasive size, and blade thickness to match the sample properties and the cutting machine parameter required a lot of testing and experimentation. Thus, in the past, resin/rubber blades had been more popular in the US market; however, in more recent years as resins have improved, there has been more of a trend towards resin bonded abrasives. Conversely, resin bonded blades have typically been more widely used in the European and Asian markets for quite some time.

Figure 2-2 Cutting blades for specific cutting requirements.

TABLE I. Abrasive Blade Selection Guidelines

Material	Composition	Recommended Blade
Soft non-ferrous metals (aluminum, brass, zinc, etc.)	Alumina / resin bonded	MAX-E
Hard non-ferrous metals (titanium, zirconium, etc.)	Silicon carbide / resin-rubber bond	MAX-C
Soft steels	Alumina / resin bonded	MAX-E
Hard and case hardened steels	Alumina / resin bonded	MAX-D
General steel and ferrous metals	Alumina / resin bonded reinforced-thin blade	MAX-D-RT
Universal thin resin / rubber blade	Alumina / resin-rubber bonded	MAX-A
Industrial general purpose thin blade	Alumina / resin bonded	MAX-I

Summary:

- Resin bonded blades - less smell, higher wear, less sample burning, more versatile
- Resin-rubber bonded blades - longer life, burnt rubber smell, more likely to burn the sample, more difficult to find the correct blade

2.2 ABRASIVE CUTTING PROCESS DESCRIPTION

Abrasive sectioning has primarily been used for sectioning ductile materials. Examples include metals, plastics, polymer matrix composites, metal matrix composites, plastics and rubbers. The proper selection of an abrasive blade requires an understanding of the relationship between the abrasive particle, abrasive bonding and the specimen properties.

Abrasive Type - Today's high performance abrasive blades use alumina or silicon carbide abrasives. Alumina is a moderately hard and relatively tough abrasive which makes it ideal for cutting ferrous metals. Silicon carbide is a very hard abrasive which fractures and cleaves very easily. Thus, silicon carbide is a self-sharpening abrasive and is more commonly used for cutting nonferrous metals.

Bonding Material - The hardness and wear characteristics of the sample determine which resin system is the best-suited for abrasive cutting. In general, the optimum bonding material is one that breaks down at the same rate as the abrasive dulls; thus, exposing new abrasives for the most efficient and effective cutting operation.

2.3 RECOMMENDED CUTTING PROCEDURES

- Select the appropriate abrasive blade.
- Secure specimen. Improper clamping may result in blade and/or specimen damage.
- Check coolant level and replace when low or excessively dirty. ***Note*** abrasive blades break down during cutting and thus produce a significant amount of debris.
- Allow the abrasive blade to reach its operating speed before beginning the cut.
- A steady force or light pulsing action will produce the best cuts and minimize blade wear characteristics, as well as maintain sample integrity (no burning).
- When sectioning materials with coatings, orient the specimen so that the blade is cutting into the coating and exiting out of the base material, thereby keeping the coating in compression.

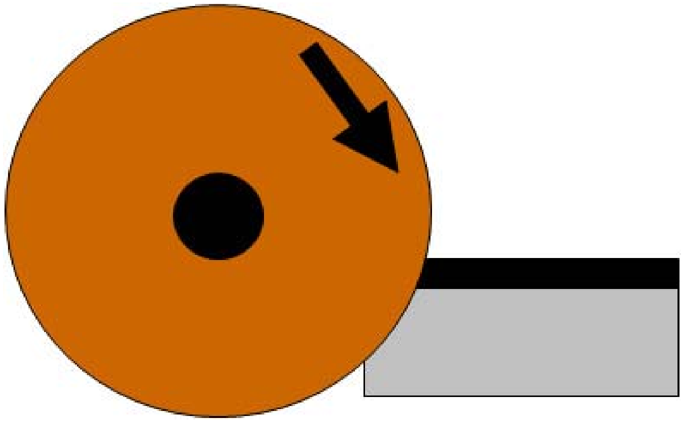

Figure 2-3 For coated samples, maintain the coating in compression when sectioning.

2.4 CUTTING FLUIDS

Lubrication and swarf removal during abrasive cutting and diamond wafer cutting are required in order to minimize damage to the specimen. For some older abrasive cutters, the proper cutting fluid can also have the added benefit of coating cast iron bases and the fixtures in order to reduce or eliminate corrosion.

TIP: Most abrasive cutters have a hood, which can produce a corrosive humidity chamber when not in use. In order to reduce these corrosive effects, keep the hood open when not in use.

Abrasive Cutting Fluid - The ideal cutting fluid for abrasive cutting is one that removes the cutting swarf and degraded abrasive blade material. It should have a relatively high flash point because of the sparks produced during abrasive sectioning.

Figure 2-4 Abrasive Cut-off Lubricants and Cleaning Agents.

2.5 ABRASIVE SECTIONING TROUBLESHOOTING

The most common problems with abrasive cutting include broken abrasive blades and cracked or burnt samples.

TABLE II. Troubleshooting Guidelines for Abrasive Cutting

Symptoms	Cause	Action
Chipped or broken blade	-Sample moved during cut -Cutting force too high	-Secure sample properly - Reduce cutting force
Bluish burnt color on specimen	-Incorrect cutting fluid -Improper blade or excessive force	-Use proper cutting fluid -Consult applications guideline or use a blade with a softer resin

Figure 2-5 MEGA-M300 Manual Abrasive Saw.

2.6 ABRASIVE CUTTING CONSUMABLES

TABLE III. Abrasive Blades (32 mm / 1.25-inch arbor) (10/pkg)

Description	10-inch	12-inch	14-inch	16-inch
Universal Thin blades	MAX-A250	MAX-A300	MAX-A350	MAX-A400
Soft non-ferrous materials (aluminum, brass, zinc, etc.)	MAX-C250	MAX-C300	MAX-C350	MAX-C400
Hard non-ferrous materials (titanium. zicronium, etc.)	MAX-C250	MAX-C300	MAX-C350	MAX-C400
Soft steels	MAX-E250	MAX-E300	MAX-E350	MAX-E400
Hard and case hardened steels	MAX-D250	MAX-D300	MAX-D350	MAX-D400
General steels and ferrous metals (reinforced-thin blade)	MAX-D250-RT	MAX-D300-RT	MAX-D350-RT	MAX-D400-RT
Industrial general purpose thin blades	MAX-I250	MAX-I300	MAX-I350	MAX-I400

TABLE IV. Abrasive Cutting Fluids

Description	Quantity	Part No.
MAXCUT Cutting Fluid (32 oz)	32 oz	MAXCUT-1000-32
MAXCUT Cutting Fluid (1/2 gallon)	1/2 gallon	MAXCUT-1000-64
MAXCUT Cutting Fluid (1 gallon)	1 gallon	MAXCUT-1000-128
MAXCUT Cutting Fluid (5 gallons)	5 gallons	MAXCUT-1000-5G
MAXCUT 2 Cutting Fluid (32 oz)	32 oz	MAXCUT2-1000-32
MAXCUT 2 Cutting Fluid (1/2 gallon)	1/2 gallon	MAXCUT2-1000-64
MAXCUT 2 Cutting Fluid (1 gallon)	1 gallon	MAXCUT2-1000-128
MAXCUT 2 Cutting Fluid (5 gallons)	5 gallons	MAXCUT2-1000-5G