Quality Matters Newsletter

Polycrystalline Diamond

PACE Technologies

Volume II, Issue 1

January 2003

by Donald Zipperian, Ph.D.

Advantages of Polycrystalline Diamond

Polycrystalline diamond is a synthetic diamond which provides better surface finishes and higher removal rates than monocrystalline diamond. Some of the more important features and advantages of polycrystalline diamond include the following:

- Higher cutting removal rates (self-sharpening abrasive)
- Very uniform surface finish
- More uniform particle size distribution
- Harder/ tougher particles
- Blocky shaped particles
- Hexagonal microcrystallites (equally hard in all directions)
- Extremely rough surface (more cutting points)
- Surface area 300% greater than monocrystalline diamond

No abrasion-resistant directionality (abrasion independent of particle orientation)

Monocrystalline blocky diamond

Polycrystalline multi-faceted diamond

Improved Surface Finishes

The primary advantage of polishing with polycrystalline diamond is the ability to consistently produce high quality surface finishes. This is particularly true for diamond particle sizes less than 6 micron in size. For polishing there are three main factors affecting the performance, these include: the size and shape of the cutting point, the particle size distribution, and the dispersion and suspending characteristics of the carrier media.

Sharp cutting points

Polycrystalline diamond has a multi-crystalline structure which means it has a large number of small sharp cutting points. These crystals are also randomly oriented so that a large number of cutting edges are oriented below the critical rake angle. For abrasive cutting angles below the critical rake angle the specimen forms a cutting chip verses a smeared or plowed cut. The formation of cutting chips produce less damage and better surface finishes. Conversely, monocrystalline diamond has a blocky shape, which results in fewer and larger, more direction-oriented cutting points. The result is that monocrystalline diamond produces large and scratches and more abrasive gouging in the specimen surface.

Particle size distribution (PSD)

In addition to the individual cutting point size discussed above, the range of the particle size (PSD or particle size distribution) plays a roll in the quality of the surface finish. Another advantage of polycrystalline diamond is in the ability to obtain tighter particle size distributions. Since the shape of polycrystalline diamond is more uniform, standard small particle sizing techniques using Stokes Law and settling techniques produce a better and more consistent particle size distribution. This is extremely important for colloidal (< 1 micron) diamond particles.

(continued on page 2)

Inside this issue:

Polycrystalline Diamond

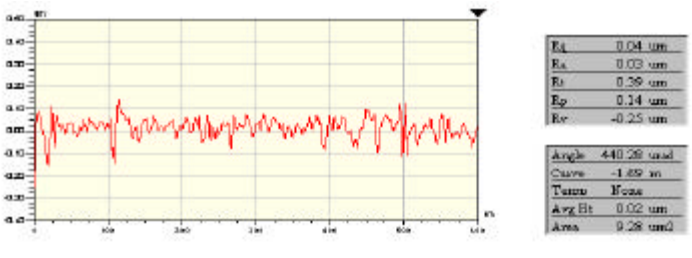
- Higher cut rates
- Improved surface finishes

Improved Surface Finishes

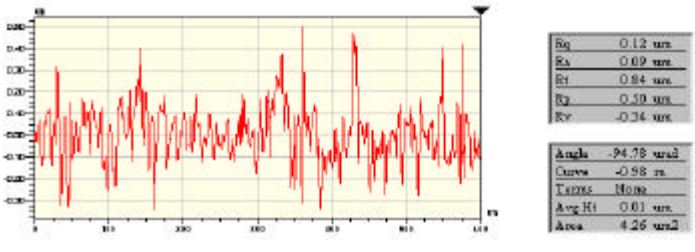
(continued from page 1)

Diamond suspending characteristics

The carrier media for polycrystalline diamond suspensions are also an important characteristic for optimizing the performance of the polishing abrasive. It is critical that the diamond be properly dispersed, otherwise unwanted particle agglomeration will result in uncharacteristically large scratching of the specimen surface. Producing these dispersions requires a sophisticated balance between the solution chemistry of the media and the surface chemistry of the diamond particles. In addition, high energy mixing using high shear mixers and ultrasonics are used to break down the agglomeration during preparation.



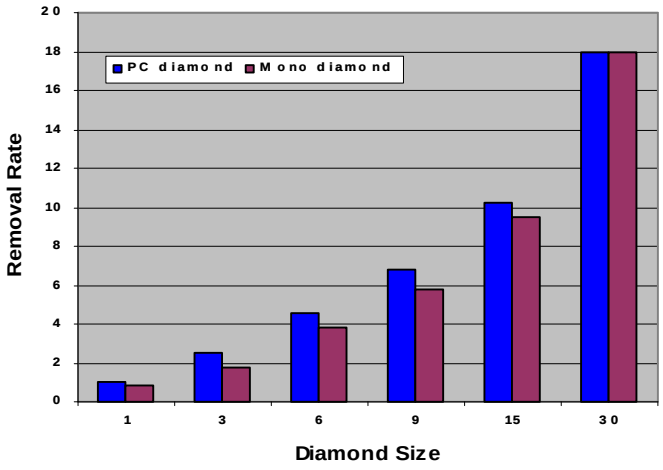
Surface roughness of a low carbon steel polished with 3 um polycrystalline diamond



Surface roughness of a low carbon steel polished with 3 um monocrystalline diamond

Improved Removal Rates

Polycrystalline diamond produces higher cut rates than monocrystalline diamond because of the larger number of smaller cutting points for comparable sized particles. This produces higher cut rates for ductile metallic specimens because there are more abrasives cutting. For ceramics, polycrystalline diamond is also more efficient because the smaller cutting areas allow for higher loads at the abrasive cutting tip, which produces greater stock removal for ceramics.



Polycrystalline vs. Monocrystalline Diamond Removal Rates

Recommended Polishing Pads

The most efficient polishing pads for polycrystalline diamond are generally low napped polishing pads (e.g. TEXPAN™, POLYPAD™, TRIDAC™ low napped polishing pads). The diamond particles tend to embed into the fiber matrix of these polishing pads which hold the abrasive for a fixed abrasive polishing mode. It is generally recommended that a lapping lubricant (POLYLUBE™ lapping lube) be used to help lubricant the polishing pad, along with aiding in removing the grinding swarf. The most efficient lubricants have some dispearsing agents to help remove the grinding swarf so it does not build up on the polishing pad.

CMP (chemical mechanical polishing)

The combination of colloidal silica and polycrystalline diamond can be used for chemical mechanical polishing or CMP. CMP polishing is the most efficient specimen preparation technique for ceramics and oftentimes for the more difficult to polish metals. The idea is to match the chemical dissolution of the specimen with its mechanical abrasion. The result is the ability to remove the damaged layer both mechanically and chemically.

Typical practice is to alternate between the application of polycrystalline diamond and colloidal silica. Prior to completing the polishing step, water or a slightly basic (pH 10) solution should be run on the polishing pad to remove the chemically reacted layer prior to microscopic analysis.

"Polycrystalline diamond provides efficiency, specimen preparation quality, and more consistent results; it's really the only choice for metallographic specimen preparation."

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

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

Where Quality Meets Value

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

PACE Technologies is an innovative and fast-growing company with a full line of metallographic and precision surface finishing products. We were the first metallographic company, in 1998, to offer online purchasing through our web site (www.metallographic.com). We continue to lead the market with customized web pages and CD's to meet our customers' needs.

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.