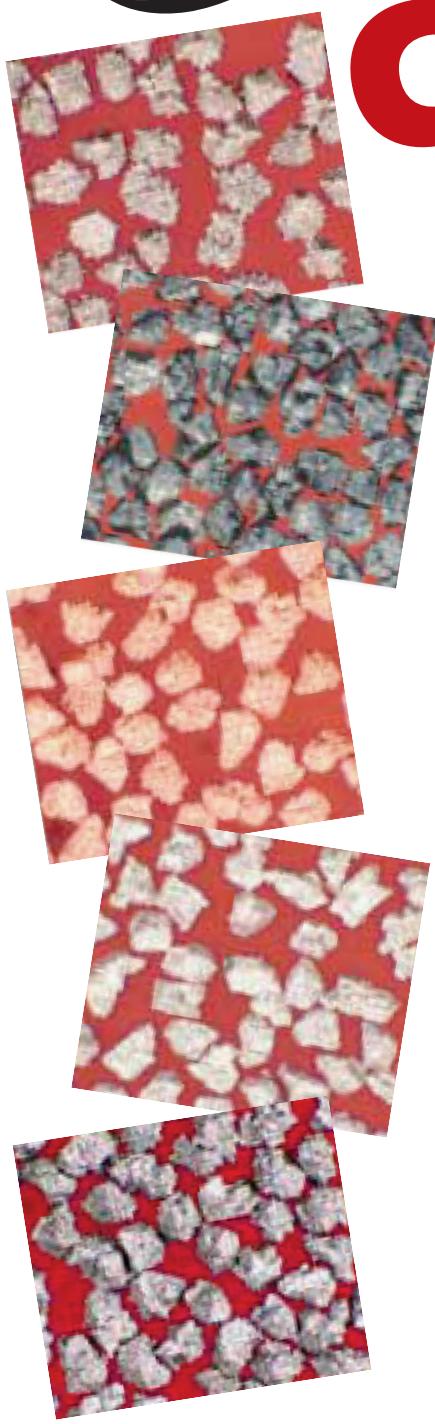
➤ BY SUSAN WOODS, FEATURES EDITOR

CRYSTAL COATINGS



Coatings for superabrasives help improve grinding wheel performance.

Coatings for superabrasives—diamond and CBN—help to improve grinding performance by addressing three problems that can arise when applying uncoated superabrasives: inadequate crystal retention, insufficient crystal protection and negative bond-system interactions. (Crystal protection and bond-system interactions are only problems with metal- and vitrified-bond systems.)

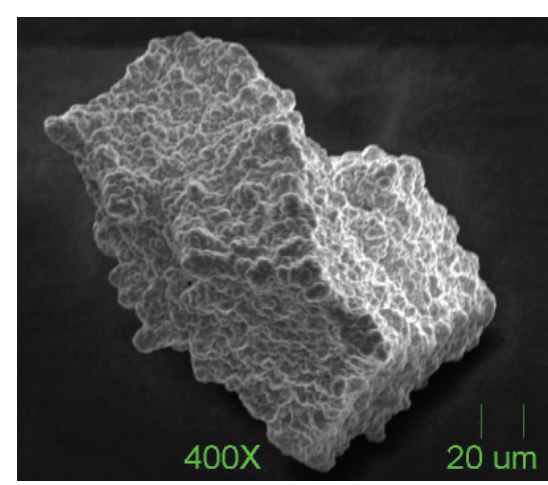
These metal-based coatings are applied to superabrasive crystals before the crystals are combined with a bond material and formed into wheels.

The primary purpose of a coating is to allow the crystal to be held more securely in the bond. How much retention is actually enhanced depends on the type of coating, as well as the bond system itself. For example, nickel coatings commonly applied to superabrasive crystals that go into resin-bond wheels enhance retention by increasing the surface area between the coated crystals and the bond system, thus increasing the mechanical adhesion between the two. This helps prevent the crystal from pulling out of the bond prematurely, which, in turn, helps extend wheel life.

Resin Bonds

Coatings for superabrasives are most commonly used in resin-bond wheels. Nickel and copper are the primary coating materials used.

Nickel is the most common material because it is relatively inexpensive and easy to apply. Copper is typically used for dry grinding because it is effective at removing heat from the grinding zone.



All images: Diamond Innovations

Magnification of a standard 56 percent nickel coating.

The coating thickness depends on the material. For copper, it is always 50 percent of the coated crystal's total weight. For nickel, it is 30, 56 or 60 percent by weight.

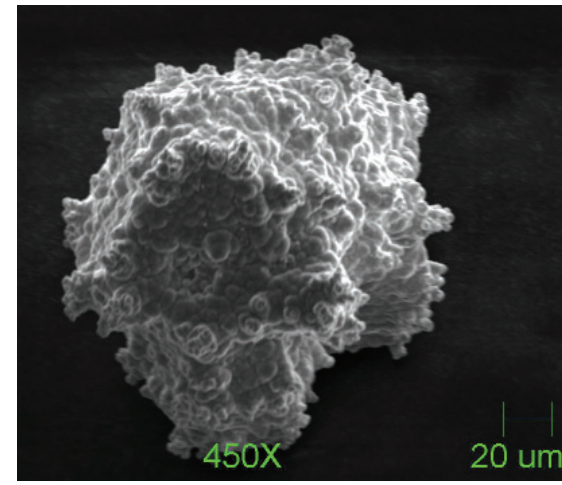
"The 30 percent does not hold onto

the diamond as well as the 56 percent, but it generates less heat," said Richard Andrews, vice president of engineering at General Industrial Diamond Co. Inc., Whippany, N.J. "Obviously, 56 percent holds onto the diamond longer, but it generates more heat. So it is a balancing act."

Silver can also be used as a coating for resin-bond wheels. Although it is expensive, it possesses desirable lubricious properties. "Silver is used primarily for grinding the flutes of carbide drills," said Tim Smith, senior development engineer at Diamond Innovations, Worthington, Ohio.

A recent development is a nickel coating that has a surface morphology composed of spikes. The spikes dramatically increase the surface area between the coated crystals and the bond system, resulting in significant gains in retention and grinding performance.

Metal, Vitrified Bonds



Magnification of the spike nickel coating. Note the stalagmite-type features of the coating, which help with crystal retention.

While most coatings are used in resin-bond wheels, some metal-bond wheels also have coated crystals. "In grinding wheels, probably 80 percent of coatings are going into resin bonds, and the rest are going into metal bonds," said Gabriel Dontu, technical support manager for Diamond Abrasives Corp., New York.

The coatings for metal-bond wheels are metal-carbide-based—meaning the carbide is formed during the coating deposition process. The most common are titanium carbide and chromium carbide. "These coatings represent the ultimate in enhanced retention, as a chemical bond is formed at the crystal/coating interface and a metallurgical bond is formed at the coating/bond interface," said Smith.

As mentioned, coatings provide additional benefits besides enhanced crystal retention. A metal-carbide-based coating also protects diamond crystals from negative bond-system interactions that can occur during the wheel fabrication process. The processing temperature of the powdered metals used in manufacturing metal bonds is much higher than the temperatures used to make resin bonds. At these high temperatures, certain bond-system constituents can attack the diamond, resulting in weaker crystals and, ultimately, decreased wheel life and performance.

"Iron, for example, can attack uncoated diamond, forming Fe_3C on the surface," said Smith. "It is then easy for the crystal to back-convert, or graphitize. Coatings can help protect the crystals from such degradational interactions."

The coating premiums for grinding wheel grits vary between 5 and 10 cents on the market, from all suppliers. However, because the coating increases wheel life, the cost is usually well worth it.

Another development on the metal-bond side is a silicon-carbide coating, called Si2. Its main purpose is to allow wheel makers to use very high percentages of iron in their bond systems and process the wheels at high temperatures with essentially no crystal degradation.

"You can use the Si2 coating to protect the crystals in a 100 percent iron bond," said Smith, "which is a much more economical choice when compared with more traditional bond materials such as cobalt, which is facing both increased price and environmental barriers to its use."

Coatings for superabrasives in vitrified-bond wheels provide the same benefits as they do in metal-bond wheels, where they help control potentially harmful chemical reactions between the crystal and the vitrified bond. Titanium is typically used for this superabrasive coating. The coating helps mitigate negative interactions that crystals might cause in the bond system itself. "Rather than protect the crystal from the bond system as in the metal bond, the coating protects the bond system from the CBN," said Smith.

The coating enhances crystal retention, as well. "The glass frits used in vitrified bonds do not 'wet,' or bond, very well with uncoated surfaces," said Smith. Putting a titanium coating on the crystal can actually improve the wetability of the crystal and aid retention.

Drawbacks

The only potential drawback to using coated superabrasives might be cost. "The coating premiums for grinding wheel grits vary between 5 and 10 cents on the market, from all suppliers," said Dontu. However, because the coating increases wheel life, the cost is usually well worth it.

The following companies contributed to this report:

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In most cases, wheels with coated superabrasives perform better than those without. Not in all cases, though. "If the wheel makers don't modify their bond to take advantage of some of the properties of the coatings, then end users may not see a difference," said Smith. "When the bond and coating are designed as a system, you see the greatest results. For instance, you want to use an iron type of bond with the Si2 coating. But if you just keep the existing cobalt bond and put the Si2 coating in, you are not going to see any difference."

How to Know

So, how do end users know if they should buy coated or uncoated superabrasive wheels? They need the advice of the wheel manufacturer or the superabrasives maker.

"We need the end user to share with us information on the application— where the wheel is going to be used and what type of bond they use—in order to recommend the appropriate concentration or the material for the coating," said Dontu.

The first thing to consider is the workpiece material. Its properties dictate the type of grit to use. The wheel maker needs to know the hardness of the material and whether it is ferrous or nonferrous, which determines if diamond or CBN should be selected. The wheel maker also needs to know the surface-quality requirements and the material-removal rates of the application.

"Designing the wheel is a step-by-step process where you always start with the application and what the finished part requirements are," said Dontu. "You have to choose the type of grit material, then the subtype of material, then the size and then the bond. Depending on that, you choose coated or uncoated." △