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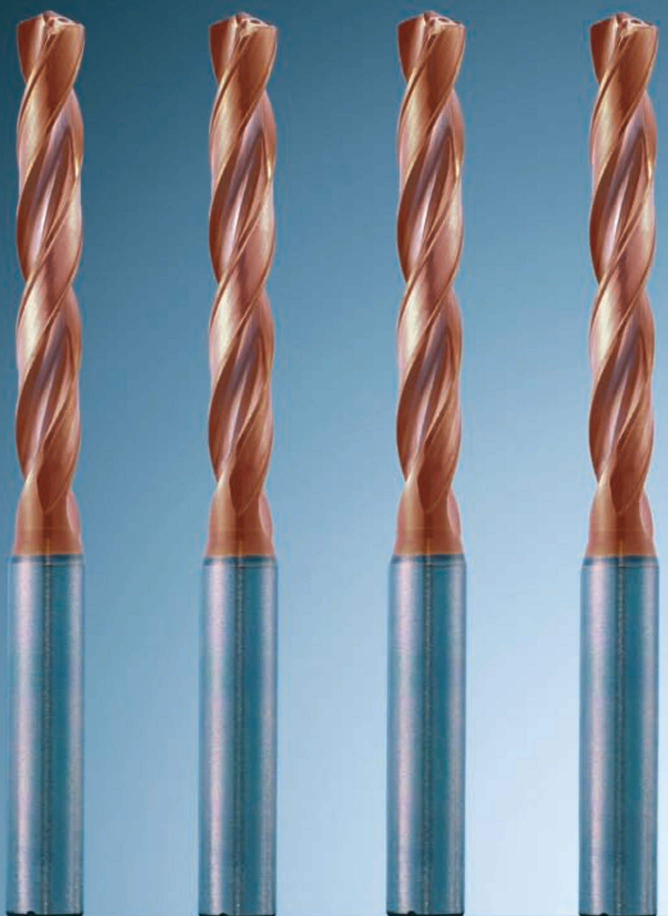
➤ BY ALAN RICHTER, EDITOR*

Recipe for Enhancement

Compared to AlTiN and TiAlN, the percentage of aluminum is higher in an aluminum-chromium-nitride PVD tool coating.



Balinit Helica is an ultrasmooth, multilayer aluminum-chromium-nitride coating specifically designed to improve the performance of drills.

Balzers

Until recently, cutting tool manufacturers and coating companies primarily focused on increasing the percentage of aluminum in a PVD coating by depositing it with TiN to form TiAlN and AlTiN (see ctemag.com/pdf/0301-raisingal.pdf). This process has been ongoing since 1995 in an effort to increase the coating's temperature resistance and hardness. By 2000, the atomic proportion of aluminum to titanium increased from about 1:2 to 3:2, or from 33 to 60 percent.

To further raise the percentage of aluminum—and after a great deal of R&D—Liechtenstein-headquartered Balzers replaced titanium with chromium and introduced aluminum chromium nitride last year. The coating company calls its single-layer AlCrN coating Balinit Alcrona. The AlCrN coating has a higher percentage of aluminum than regular AlTiN compositions. AlCrN is applicable to a range of HSS and carbide cutting tools, including hobs, endmills and milling inserts. In addition, it is suitable for turning tools, but only for extremely heat-resistant and diffusion-stable substrates such as PCBN and Si_3N_4.

For holemaking, Balzers introduced a multilayer AlCrN coating that it calls Balinit Helica at EMO Hannover 2005. The ultrasmooth coating can be applied to any carbide or HSS drill to provide enhanced abrasion resistance and extra shear strength, as well as facilitate chip evacuation. Whereas the 3µm- to 4µm-thick monolayer coating is seen as a continuous structure when viewed under a scanning electron microscope

(Figure 1), Helica's distinct layers are clearly visible when seen in an SEM image (Figure 2). The multilayer coating also has a total thickness of around 4µm, except for drills smaller than ⅛" in diameter where a 1µm- to 2µm-thick coating is more appropriate.

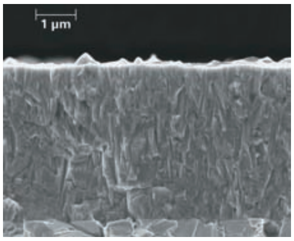


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Figure 1: A scanning electron microscope image of the fracture cross-section of the Balinit Alcrona coating on a carbide substrate shows the AlCrN coating's monolayer structure.

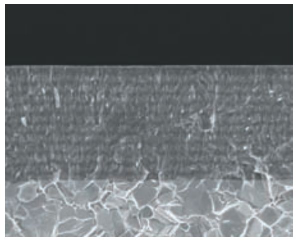

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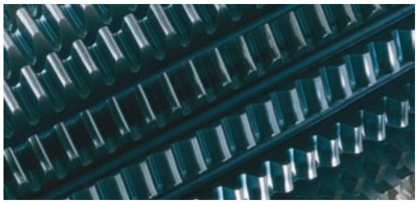
Figure 2: Also an AlCrN coating, Balinit Helica's distinct layers are clearly visible when seen in an SEM image.

Heat Shield

Although a 100 percent PVD Al_2O_3, or pure alumina, coating would provide the maximum amount of heat-shielding in a coating, such a coating isn't widely available. (In both AlTiN and AlCrN coatings, the AlN portion "converts" to Al_2O_3 during machining.) Patents exist for a PVD Al_2O_3 coating and tools are able to be PVD-coated with Al_2O_3 using, for example, a small, laboratory-scale reactor with alternating current or pulsed direct-current power supplies, but it's problematic to accomplish on a commercial scale in a large reactor. This is because, unlike all the other coatings that are electrically conductive, alumina is electrically insulating. [*Editor's note: Walter AG, Germany, introduced its Tiger•tec PVD Al_2O_3 coating at EMO.*]

Therefore, the PVD coating process, which is plasma-activated, requires some electrical biasing during coating deposition. This means an electric potential must be applied between the tools to be coated and the plasma. All in all, alumina's insulating properties make the PVD process quite difficult to control and uneconomical for Al_2O_3.

AlTiN coatings have reached a practical maximum aluminum content of about 65 percent due to a structural-stability limit. Too much aluminum in a TiN-based coating causes the coating's crystal structure to change from cubic to hexagonal lattice. A CrN-based coating, on the other hand, can hold more aluminum without AlCrN's structure changing.



Samputensili

Because the process generates a lot of heat, dry hobbing is an appropriate application for an AlCrN coating, such as the Sunite Alcrona coating from Samputensili S.p.A., Italy. The coating is deposited on tools using a Balzers furnace.

Like any coating, AlCrN's ability to resist deformation is a function of the lattice structure of the material. With a cubic structure, a coating is able to retain its high hot hardness—its ability to remain hard while exposed to the elevated temperatures at the tool/workpiece interface. Once the coating flips to the hexagonal structure, the hardness goes down because the coating can no longer resist deformation. For TiAlN, the hardness begins to drop off dramatically at about 800° C, and for AlTiN, it's less than 900° C. Whereas for AlCrN, it retains its hardness until the temperature reaches 1,100° C, and even at that temperature the coating protects the substrate from the harmful effects of oxidation. The hardness level for this group of coatings is 2,800 to 3,200 HV at an indention load of 50 g.

Soft and Gummy

The AlCrN coating's higher hot hardness means the coating is stable even under an extremely high thermal load and AlCrN-coated tools generally perform better than other types of coated tools, especially at high-speed, dry or near-dry machining conditions. For example, when finishing a Ck45 steel workpiece at both 200m/min. and 400m/min., AlCrN-coated milling cutters attained a substantially longer service life than TiAlN-coated tools in tests performed at Balzers Cutting Laboratory.

The exception is machining materials with a hardness of 54 HRC or greater, such as mold steels. When cutting those materials, an AlTiN coating is as good as or superior to an AlCrN coating (see sidebar, page 44).

However, when machining less hard alloy steels or cast iron, AlCrN-coated tools are more effective than AlTiN-coated cutters. This is the case even

A toolmaker's take

One cutting tool manufacturer was coating its indexable inserts for rough, semifinish and finish milling of tools and dies with AlTiN and TiCN. AlTiN was used for most applications, but TiCN-coated inserts were used for applications with low to medium operating temperatures where chatter was a concern.

Then, Balzers' Balinit Alcrona, or aluminum-chromium-nitride, coating was suggested for tools machining steels less than 54 HRC. The toolmaker also found the AlCrN coating to be an "excellent choice" for cast iron and some stainless steels. AlCrN was recommended for lower-hardness materials because when cutting materials harder than 54 HRC, an AlTiN-coated tool lasts 20 to 40 percent longer than an AlCrN-coated one. In addition, an AlTiN-coated tool costs about 25 percent less than a tool coated with AlCrN.

When cutting materials below 54 HRC, the cutting speeds and feeds for AlCrN-coated tools are comparable to that of AlTiN-coated cutters, but the AlCrN coating extends tool life 25 to 100 percent. And because of AlCrN's lower coefficient of friction, chip adhesion and heat generation are reduced.

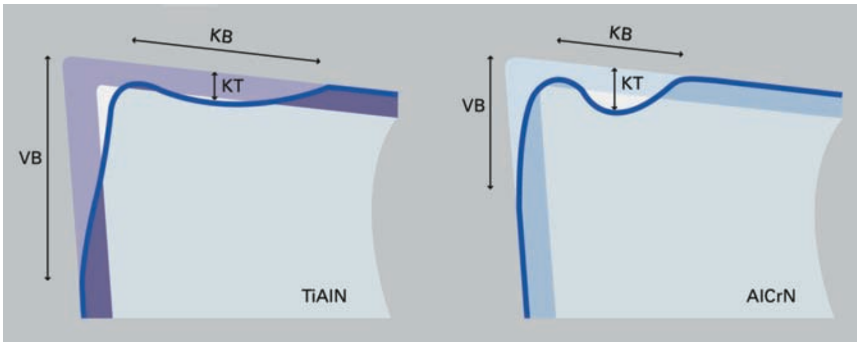
"Our customers who were using the AlTiN coating for softer materials are consistently switching to the Alcrona coating due to improved tool life," the toolmaker said.

—*A. Richter*

when cutting gummy materials, such as low-carbon and stainless steels.

AlCrN-coated tools are also recommended for machining long-chipping materials, such as stainless steels. This is because there is more contact on the tool's rake surface during chip formation, which generates a lot of heat due to the increased contact between the tool and workpiece.

In addition, an AlCrN coating leads to a change in the tool wear and chip-formation behavior when machining compared to a TiN-based coating. AlCrN displays markedly less flank wear than TiAlN, and the cratering width is smaller (Figure 3). However, the cratering depth is greater for AlCrN because the chip cut with an AlCrN-coated tool curls more tightly, with a decreased contact length on the rake surface. The AlCrN's high abrasion resistance and high hot hardness result in slower wearing in of the coated flank and face zones. Finally, the cutting force applied to the tool acts more localized and closer to the edge. △



Balzers

Figure 3: A comparison of wear analysis for a TiAlN-coated tool and an AlCrN-coated tool, which shows flank wear (VB), cratering width (KB) and cratering depth (KT).

Based on information provided by Dr. Dennis T. Quinto, technical director for Balzers Inc., Elgin, Ill. For more information about the company's tool coatings, call (800) 792-9223, visit www.bus.balzers.com or* ***enter #410 on the Information Services card.*

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