

Top Coat

► BY ALAN RICHTER, MANAGING EDITOR

Molybdenum disulfide tool coatings improve the machining of aluminum, titanium and nickel-base alloys—even when dry.

Analogous to paper in a game of rock, paper, scissors, a “soft” and lubricating molybdenum disulfide (MoS_2) tool coating covers a hard tool coating or substrate, giving the machinist the upper hand. Likewise, cutting edges gain the advantage when an MoS_2 coating is thrown into play.

This is certainly the case when machining—especially dry machining—aluminum alloys, alloyed steels, nickel-base superalloys, titanium alloys and copper, according to Don Rancic, coating process engineer for Guhring Inc. He added that an MoS_2 coating fights built-up edge and chip packing and retains its lubricating properties even under extreme-loading conditions.

The coating is appropriate for virtually all machining operations. Some of the more demanding applications include small-diameter drilling and reaming, deep-hole drilling, hobbing, broaching and tapping. Guhring, Brookfield, Wis., offers MolyGlide, a dry thin-film “integrated lubricant” based on MoS_2 . Rancic noted that for one application that involved tapping 4130 alloyed steel, average tool life increased from 400 holes to 1,100 holes after the steam-oxide-treated 10-32 taps were coated with MoS_2 .

The toolmaker reports that MolyGlide is applied via a physical vapor

deposition, modified magnetron sputtering process. The high-vacuum process is performed at a relatively low temperature (305°F). The coating, which has a microhardness of 20 to 50 HV, is deposited $1\mu\text{m}$ thick over a hard coating, such as titanium nitride, titanium carbonitride or titanium aluminum nitride, or a bright tool.

Rancic explained that MoS_2 has a dendritic, or treelike, crystal structure, similar to graphite, with weak bonds between the crystal layers. This allows easy movement of the planes of the crystal layers (Figure 1). “When you use a molydisulfide-coated tool, the coating tends to move,” he said. “Even when it appears to the naked eye that the coating has been worn off, it still retains its effectiveness.”

In addition to cutting tools, Rancic noted that the MoS_2 coating offers a dry, cost-effective alternative to oil-based lubricants for many load-bearing precision components and wear parts. The coating reduces adhesive wear and seizure. And because the MoS_2 coating

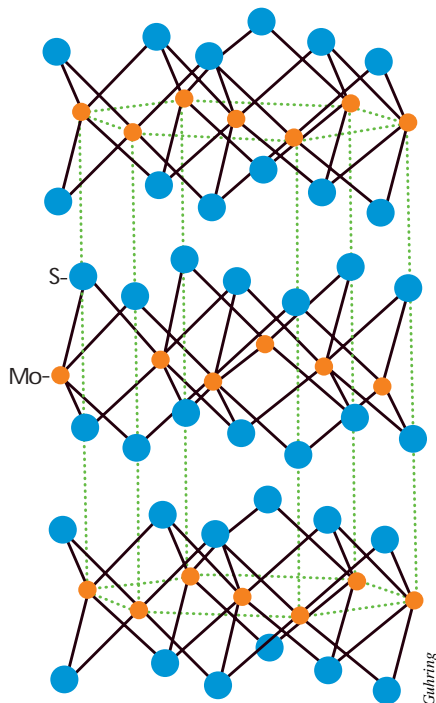


Figure 1: With a hardness comparable to talc or chalk, an MoS_2 tool coating performs as a solid lubricant because the weak bonds between its crystal layers allow easy movement of the planes.

	MICROINCHES	INCHES	ANGSTROMS	MICRONS	MILLIMETERS
MICROINCHES	1	0.000001	250	0.025	0.000025
MICRONS	40	0.00004	10,000	1	0.001
MILLIMETERS	40,000	0.04	10^7	1,000	1

Approximate conversions for coating thickness units.

Guhring

Surf Tech

is deposited at a low temperature, low- and medium-carbon alloy components can be coated, which wouldn't be possible via a high-temperature PVD process.

Avoiding Heat-Affected Zones

Surf Tech is another company that deposits a PVD MoS₂ coating on cutting tools, as well as wear parts and molds for the plastics industry. Ed Yusko, who's in charge of operations, said the Austinburg, Ohio, company



Micrographs of a coated drill showing the wear to the top-layer MoS₂ coating after 50 rotations (top) and 400 rotations.

applies MoS₂ coatings at temperatures of 250° F or below. The low temperature allows brazed tools to be coated without degradation of the brazed area.

"We've coated a variety of carbide-, CBN- and PCD-tipped tools," Yusko said. "The coating extends the tool life and improves the surface finish."

He added that on tools used to machine aluminum, titanium, brass and copper, the coating prevents the material from sticking to the cutting tool. On

tools used to cut harder materials, the coating helps dissipate heat, thereby, maintaining the cutting edge.

Yusko explained that the patented 1µm- to 4µm-thick coating is composed of multiple thin-film nanolayers, each of which is measured in angstroms. (One angstrom is equal to one 10-millionth of a millimeter.) "Depending on the type of coating we're applying and its thickness, we can have upwards of 1,200 layers," he said.

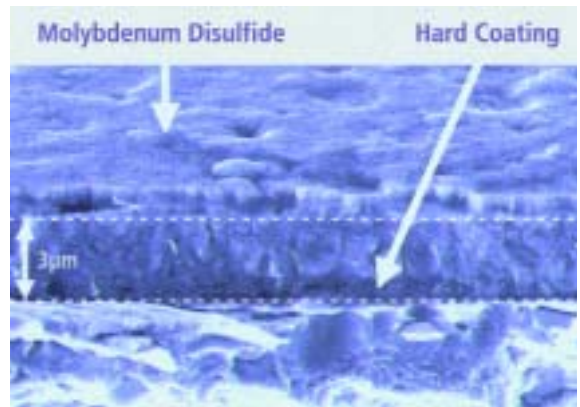
After the tools or components are received and inspected, they go through a multistage ultrasonic cleaning process, using aqueous solutions. Next, they are fixtured and loaded into the equipment, where an ion gun is used in place of biasing to ensure proper bonding of the coating to the substrate. Biasing is a means of employing an electrical charge to aid adhesion.

"We'll actually mill off a couple of angstroms of material from the entire surface being coated to ensure we are down to the base material and don't have any type of oxidized surfaces or contaminants remaining," Yusko said.

Yusko pointed out that the ion-assisted deposition method also keeps the temperature low. The low temperature prevents the substrate from annealing and maintains its dimensional stability. "When you bias a part, you're causing the temperature to increase in that part."

In addition, the Surf Tech process allows up-sharp edges, which often are honed to help a hard coating adhere to the edges, to be coated without altering edge geometry. This is beneficial when machining aluminum, which is best cut by tools with up-sharp edges.

Yusko said the company's uniformly deposited coating process overcomes this dilemma. "A lot of tools used for machining aluminum have very fine



In addition to coating bright tools, Guhring also applies the MolyGlide coating on hard coatings, such as TiN, TiCN and TiAlN.

finishes on them, especially the flutes," Yusko said. "Our process doesn't affect the microfinish or produce any type of buildup on the sharp edges, as do some of the other PVD coatings offered."

He added that Surf Tech has coated 0.005"-thick razor blades without altering the cutting edge.

An MoS₂ coating is not soluble in water, so MoS₂-coated tools can be used with conventional coolants and oils. However, Rancic said that since the coating functions as a lubricant, it significantly improves tool performance when run dry and near-dry.

"The coating helps some of our customers do dry machining," Yusko concurred.

Yusko and Rancic also agreed that MoS₂ coatings, which both companies introduced in 1995, are being deposited on more cutting tools. "We've seen increased activity in the areas of broaches, gundrills and gear hobs," Yusko said.

Companies that contributed to this report:

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