MARKET DEVELOPMENT LEADING EDGE TECHNOLOGY

HARD, LOW-FRICTION COATING FOR TOOL APPLICATIONS

At Hauzer, we are always looking for better coatings for specific applications. For tools to form and cut non-ferrous metals and plastics, the best coating is hard, with a low coefficient of friction, reducing built-up edge and keeping the cutting edge sharp. Cutting tests show that one of the diamond-like carbon (DLC) coatings, the tetrahedral amorphous carbon (ta-C) coating, applied with HiPIMS is an excellent solution for this application and many others.

Excellent Properties for Tool Coatings

Hauzer developed ta-C by HiPIMS as part of Pegasus, a European project in the automotive industry (see HFY 27, article HiPIMS Carbon Coatings by Ruud Jacobs). Since ta-C coatings in tool applications showed positive results, we put HiPIMS ta-C to the test for tool coatings as well. The results are excellent: in a cutting test, machining two different aluminium alloys, the coating outperformed the benchmark by roughly a factor of two.

In applications where an extremely sharp cutting edge is required, such as cutting non-ferrous metals and plastics, a thinner coating means the tool can remain sharper. With the high hardness of ta-C, a coating thickness below 1 µm micrometre is typically sufficient on cutting tools such as drills, taps and end mills. The low sticking coefficient of the ta-C coating leads to less adhesion of aluminium to the tool, a reduced built-up edge, a sharper cutting edge and an increased tool performance lifetime. This is also evidenced by reduced torque during the machining operation.

Solving Deposition Drawbacks

By now, ta-C coatings have been known for almost two decades. They are used in automotive applications, for example on tappets and piston rings. In the tool industry, the demand for the highly recognisable rainbow-coloured ta-C coating deposited by arc technology is growing. However, the number of applications has so far been limited due the available deposition technologies. Cathodic arc evaporation technology is the traditional ta-C deposition method, with arc discharge generated on circular arc cathodes equipped with graphite targets. Ionised carbon atoms are used to bombard the negatively charged products.

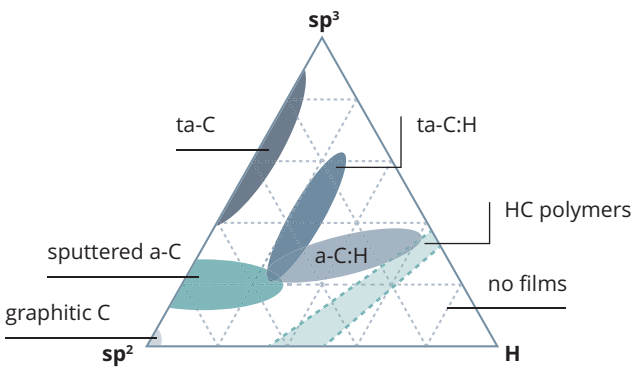
The resulting ta-C coating has a very high hardness (HV > 5000), but is also a little rougher due to generation of macro particles (droplets). For many applications, this does not affect performance. But for applications where smoothness is of the essence, such as taps and micro-tools, this deposition method does not always achieve the required results. Post-treatment polishing is not always possible with ta-C coatings.

Filtered arc evaporation is another deposition mode for ta-C, used to decrease coating roughness. In this method, carbon ions are steered towards the tool with a magnetic filter. The carbon macro particles – neutral in charge – will not bombard the tool. However, filtered arc evaporation is expensive: the equipment cost is high and the deposition speed is relatively low. Moreover, some macro particles will deflect in the magnetic duct and still reach the substrates.

HiPIMS: the Best of Both Worlds

HiPIMS technology offers the benefit of an ion-producing deposition methodology and the smoothness of sputter coatings. With the introduction of the latest generation of power supplies and the possibility to program pulse trains with pulse width modulation, Hauzer's HiPIMS technology is now also suitable for target materials such as graphite, making the deposition of hard hydrogen-free carbon coatings with HiPIMS a reality.

HiPIMS-deposited ta-C coatings have an excellent combination of hardness, low coefficient of friction, smoothness and low adhesion of workpiece material to the cutting tool. Based on these characteristics, we foresee a promising future for ta-C coatings in a growing range of applications in cutting and forming tools.



J. Robertson, Materials Science and Engineering, 2002 (129-821)

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Diamond-like carbon (DLC) coatings come in many varieties, classified by their ratio of sp3-bonded carbon (diamond), sp2-bonded carbon (graphite) and hydrogen. The more sp3-bonded carbon in a coating, the harder it usually is. Tetrahedral amorphous carbon (ta-C) is a hydrogen-free carbon coating with high sp3/sp2 ratio (on the left side of the triangle.)

APPLICATIONS OF TA-C

- Tool coating: especially for cutting and forming tools of non-ferrous metals and plastics. This market will likely continue to grow, thanks to the push for reduced weight in automotive and other sectors and the rise of novel materials such as carbon-fibre-reinforced plastics (CFRP).
- Tribological coating: the low coefficient of friction and excellent temperature resistance of ta-C coatings make it very interesting for tribological applications as well. In automotive, for instance, reducing friction can improve engine efficiency, reduce fuel consumption and lower CO_2 emission.