Next-generation coatings

A scalable pulsed power plasma process is enabling application of hydrogen-free diamond-like carbon coatings that offer increased hardness and reduced friction

Baliq combines the advantages of arc and sputtering technologies, which are high ionization and almost 100% droplet-free coating

The ambition to go beyond limits is a defining characteristic of manufacturers of supercars, motorbikes and of professional racing teams in motorsport because of the highly competitive markets in which they compete worldwide.

Among the most demanding environments in high-performance vehicles are the high-friction, wear and contact areas of the engine and valvetrain, where there is high contact pressure and sliding speeds. Coatings play a pivotal role in this through reduced friction level, and reduced wear thanks to increased hardness.

However, utilizing coatings to increase performance and lifespan of key components is complex, as coatings must work within a tribological environment of friction, lubrication and wear.

To date, the performance standard for coatings in this environment has been diamond-like carbon (DLC) coatings. These coatings are produced through plasma-assisted chemical vapor deposition (PACVD), which produces extremely hard, yet thin, coatings that provide high adhesion to substrates, while providing hardness and reducing friction. Within this coatings family, the majority of coatings are made of amorphous carbon with hydrogen (a-C:H).

"Although today's a-C:H coatings can be produced at high volume for low prices, in terms of their design properties they are already reaching their performance limits," says Marc Hervé, motorsport segment manager, Oerlikon Balzers.

Hydrogen-free coatings are made using a physical vapor deposition (PVD) by arc method, which produces tetrahedral amorphous carbon (ta-C). Although this can be used to create a very dense, hard coating with high adhesion, the process produces small droplets that contribute to a rough surface finish. As a result, coating manufacturers must complete secondary polishing processes to smoothen the surface. Because of its hardness, it is a time-consuming and expensive process.

"Fortunately, recent advancements in the development of harder, yet smoother DLC coatings are being driven by refinements in the application process," adds Hervé.

In a proprietary process developed by Oerlikon Balzers, the DLC coating can be applied using scalable pulsed power plasma (S3p), which combines the advantages of the arc evaporation and sputtering methods. Arc evaporation is known for producing dense coatings with high adhesion. Sputtering, a conventional coating technology where atoms are ejected from a target or source material to be deposited on a substrate, is known for high levels of smoothness.

The result is a hydrogen-free DLC coating that delivers a unique combination of high hardness, low friction and a smooth surface. The S3p technology generates a high level of tetrahedral bonds with hardness up to 40GPa.

As such, the coating – Baliq Carbos – provides the hardest surface coating within the category and up to double the hardness of current DLC coatings. The coatings exhibit three times lower abrasive wear than a 20GPa hard DLC coating as measured by a calo test.

Unique to the extra-hard Baliq Carbos coating is that it delivers both the low friction of carbon coatings and the smoothness typical for coatings applied in the sputter process, achieving the same smoothness – Ra = 0.03μm – as other sputter or PACVD coatings. Moreover, the smoothness is achieved without additional polishing treatments, saving time and cost.

The coating process operates at a relatively low temperature, below 200°C (392°F), compared with up to 350°C (662°F) for other DLC coatings. This enables application to a much wider panel of materials, bonding effectively to aluminum and steel substrates. Opening up more options for coating applications and the higher hardness directly translates to longer component service life.

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