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Plasma-Assisted Surface Coating

Processes, methods, systems and applications

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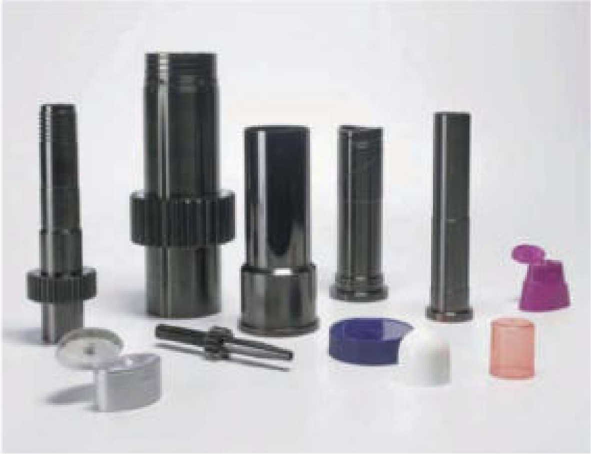

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Outlook

As noted before, industrial plasma-surfacing technology has developed rapidly in the past few decades in order to meet the rising demands made on functional surfaces. New challenges will in future drive the further development of existing coating technologies and of new layer concepts and applications.

Coating technologies

Arc PVD and sputter processes will continue to develop via the use of new evaporator and sputter-source concepts and of pulsed technology. Micro-alloyed and multistructured layers which permit complex, application-specific layer design can be generated by means of ultra-dense plasmas, employing optimized arc-evaporator technology, including the development of innovative evaporator materials. Nanodesign of layers will be one of the development tools.

In the field of sputter technology, high-energy pulsed plasmas are currently the focus of development, with the aim of replacing conventional DC sputter technology in specific areas; however, industrial application has only just started. In terms of ionization of the sputtered material, sputter technology has now reached the point at which Arc PVD technology started in the early 1980s. The high-current pulsing of magnetrons will in the future rationally augment the spectrum of industrial plasma coating processes in certain sectors.

Ion sources

The development of sources (evaporators and magnetrons) is continuing apace, with increased efficiency and productivity the target. Planar and rotating cylindrical magnetron sources, the magnetic fields of which can be

variably adjusted, and magnetic field intensity and alignment optimally matched to the particular process variant, are being further developed in the form of arc-evaporators, sputter sources and combined sources for arc and sputter operation. Sophisticated electrical circuiting of the evaporators with one another or with suitable counter-electrodes (additional plasma excitation) will by means of serial and sequential operation permit not only a reduction in the number of power supplies necessary, but also utilization of the sources for electron heating, effective ion cleaning and coating. The necessary power supply systems will need to be further optimized – or re-engineered – in parallel to the developments mentioned here.

Layer materials and their combinations

The combination of Arc PVD and magnetron sputtering processes, also in conjunction with PACVD, promises the largest possible diversity of future innovative layer materials and their combinations, including oxides and other non-conductive materials, multilayers, nanostructured layers, nanocomposites, gradient layers and microalloys. Alongside the classical layers, new layer chemistries such as TiSiXN, for example, will increasingly be applied, the atomic number of the elements used now having reached that of the lanthanides. This is the precondition for tailor-made multifunctional properties which permit significant improvements over the traditional layers.

Multicomponent systems and adaptive layers, whose composition and structure modify to optimally match the prevailing environmental conditions, are also interesting concepts which must be pursued. Thick (20 to 50 µm) PVD anti-wear layers are already well established on engine components and as anti-erosion layers. Layer thicknesses of 10 µm and more will also come into wider use for selected precision tools. Optimum pre- and post-treatment will play a key role in this field. The post-treatment of anti-wear-coated precision tools and components will be an element in every conceptual solution, irrespective of the deposition process used to apply them.

The use of atmospheric plasmas for the synthesis of high-performance layers, which at present can be applied only using PVD technology under high vacuum, will in future augment system engineering and process technology in a number of fields.

DLC layers

In carbon-based tribological layers, i.e. the "DLC" layers, rapid development towards tailor-designed, systematically nanostructured, optimized layer-thickness multilayers will continue. PACVD processes, in combination with PVD processes in many cases, will play a central role. Super-hard hydrogen-free ta-C layers for the most diverse range of applications will be at the focus of innovation, alongside the hydrogen-containing DLC layer types.

Coating machines

Small to medium-sized coating machines will become established, depending on application and the number of layers to be alternately deposited and the components and tools to be coated.

As a key and cross-sectional technology, plasma coating will continue to generate innovations that guarantee viability also in the future.

Glossary

a-C Hydrogen-free amorphous carbon layers (recommended abbreviation).

a-C:H Hydrogen-containing amorphous carbon layers (recommended abbreviation).

a-C:H:Me Metal-containing hydrogen-containing amorphous carbon layers (recommended abbreviation).

a-C:H:W Tungsten-containing hydrogen-containing amorphous carbon layers (recommended abbreviation).

a-C:H:X Modified hydrogen-containing amorphous carbon layers (recommended abbreviation).

AEGD Arc Enhanced Glow Discharge.

APA Advanced Plasma Assisted.

Batch machine Intermittently operated machine.

CVD Chemical Vapour Deposition.

DC Direct Current.

DLC Diamond-Like Carbon or Diamond-Like Coating; collective term for (hard) amorphous carbon layers.

Droplets Microscopic globules of the cathode material, which are generated in the plasma coating process and incorporated into the layer.

Gradient layers Layers in which properties and compositions change across layer thickness.

HCPMS High-Current Pulsed Magnetron Sputtering.

HIPAC High-Ionization Plasma for Advanced Coatings.

HIPIMS High-Power Impulse Magnetron Sputtering.

HPPMS High-Power Pulsed Magnetron Sputtering.

HRC Rockwell hardness.

HSS High-Speed Steel.

HV Vickers hardness.

Maraging steel From “martensite ageing”.

MF Medium-frequency.

Monolayer Layer with properties constant across layer thickness.

Multilayer Layer consisting of several individual layers.

Nanocomposites Multi-phase materials in which one phase is present in the form of nanoparticles (< 100 nm) finely dispersed in a solid matrix.

Nanolayer Multilayer with individual layers in the nanometre range.

PACVD (also PECVD) Plasma Assisted (or “Enhanced”) Chemical Vapour Deposition.

Plasma Fourth physical state of matter. The term is generally used when a gas consists, as a result of input of energy, partially or entirely of free charge carriers such as electrons and ions, and is thus electrically conductive.

Precursors Here: gaseous reactants in ↑*CVD*.

PVD Physical Vapour Deposition.

RF Radio frequency.

Substrate The workpiece to be coated (part, component, tool).

ta-C Tetrahedral, hydrogen-free amorphous carbon layers (recommended abbreviation).

TiSiXN TiSiN layer with additional application-specific elements X.

W-C:H Alternative abbreviation for ↑*a-C:H:W*.