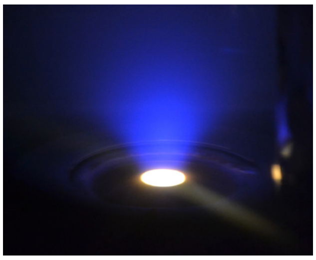
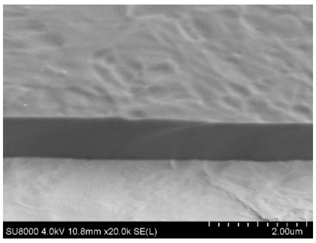
ta-C coatings using anodic arc evaporation

Anodic arc evaporation of graphite enables the deposition of high-quality, droplet-free and smooth ta-C coatings with application potential for hard coatings, in particular. Deposition rates of up to 18 nm/s have been achieved.



Process photo of the anodic arc evaporation of graphite



SEM image of a smooth and droplet-free ta-C layer on a steel substrate

Tetrahedral amorphous carbon (ta-C) is one of the most promising modifications of ‘diamond-like carbon’ materials. Hydrogen-free ta-C coatings are chemically inert and are characterized by high hardness, thermal stability, thermal conductivity and low coefficients of friction. These properties open up a wide range of applications, in particular as wear-resistant coatings for tools, components and automotive parts, and as diffusion barriers in hydrogen technology.

Various processes have already been established for the deposition of ta-C coatings. In arc-based processes, however, characteristic droplets or particles are emitted and embedded in the coatings. These impair the coating properties and can only be reduced using complex filter techniques.

The Fraunhofer FEP has developed a physical vapor deposition process that uses a hollow cathode arc discharge as an electron source and enables the anodic arc evaporation of graphite for the deposition of hydrogen-free carbon layers. By applying a bias voltage, the particle energies can be increased and the layer properties customized. The layers deposited on steel substrates with thicknesses of 500 – 800 nm were analyzed using nanoindentation, Raman spectrometry, FE-SEM, AFM and spectroscopic ellipsometry. The analyses show a high proportion of tetrahedral sp^3 bonds of 70 – 88%. The energies of the vapor particles are high enough to achieve high hardness values of 61 – 75 GPa and a Young’s modulus of 588 – 685 GPa at substrate temperatures below 200°C, even without bias voltage. The coatings are droplet-free and are characterized by low surface roughness. The deposition rates of 4 – 18 nm/s are exceptionally high for ta-C coatings, which emphasizes their suitability for industrial applications. The ta-C coatings with high hardness and smooth surface are very well suited for wear-resistant surfaces.

The innovative coating process can be easily scaled in terms of coating width by arranging several evaporator modules in a row. The process is also suitable for other materials and applications, such as the low-damage deposition of transparent conductive oxides.

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