OR0504

A Novel Approach to Evaluate Adhesion of Superhard Carbon Coatings using the scratch test method

Martin Zawischa[1], Stefan Makowski[2], Volker Weihnacht[2], Andreas Leson[2]

[1]Technische Universität Dresden, Dresden, Germany [2]Fraunhofer Institute for Material and Beam Technology IWS, Dresden, Germany

martin.zawischa@iws.fraunhofer.de

A strong adhesion to the substrate is essential when applying hard PVD coatings like tetrahedral amorphous carbon (ta-C) on tools or components. Therefore, a realistic assessment of coating adhesion is one of the main challenges in production and research. For this purpose, the scratch test according DIN EN 1071-3 and ASTM C1624 is commonly used, enabling a comparative classification by critical load parameters based on different coating failure mechanisms. The phenomenologically determined critical loads are known for their limited comparability due to their dependence on coating thickness, coating hardness, as well as yield strength of the substrate material. This constitutes a major drawback of the described method.
In this work, ta-C coatings with a typical thickness of 1 µm to 3 µm and hardness up to 80 GPa are examined by standard scratch testing, using a diamond indenter with 200 µm radius. An overview of the different failure mechanisms of those superhard coatings, depending on scratch-indenter radius and coating thickness, is presented. Coating delamination mainly results from plastic substrate deformation which typically does not represent the delamination situation in real applications.
A new evaluation method quantifying the area of adhesive failure in the non-plastic zone by means of optical segmentation is discussed. From this optical evaluation a new parameter for adhesion strength is obtained, which is independent from coating thickness within a certain range. By this new method it became possible to clearly distinguish different coating processes regarding their effects on adhesion improvement of ta-C coating.
Furthermore, the stress situation at the beginning of adhesive coating failure is calculated. The shear stresses at the interface are found to strongly correlate with the area of delamination.

Keywords
scratch test
ta-C
DLC
adhesion
delamination