PO2049

Understanding adhesion of Diamond-like Carbon coatings on steel substrates for use in high pressure Diesel injection systems at elevated temperatures

Richard Braak[1], Ulrich May[1], Leni Onuseit[1], Gernot Repphun[1], Marcus Guenther[1], Jens Emmerlich[1], Christoph Schmid[2], Karsten Durst[2]

[1]Robert Bosch GmbH, Stuttgart, Germany [2]Physical Metallurgy, TU Darmstadt, Darmstadt, Germany

Richard.Braak@de.bosch.com

Modern fuel efficient Diesel injection systems rely on amorphous hydrogenated carbon coatings (a-C:H) for wear protection. Higher fuel efficiency is achieved by increasing the injection pressure and thereby the power density in the combustion chamber. As in current common-rail injection systems pressures of 2000bar and temperatures of 300°C are exceeded, new coating technologies are required for further enhancing the lifetime and fuel efficiency of the engines. For this reason hydrogen free amorphous carbon with high sp_3-content (ta-C, abbr. for tetragonal amorphous carbon) represents another candidate for the functional layer, due to its even higher hardness compared to a-C:H. Adhesion is crucial for such a layer system to fulfill its task over a long lifetime. With higher stresses not only the requirements on the functional layer are increased but also on its adhesion to the substrate. In this study different systems of adhesion layers for both a-C:H and ta-C are tested systematically before and after annealing at 350°C. As there is no universal benchmark for the adhesion of tribological coatings, several techniques have been used and compared in order to study the adhesion performance. These techniques include widely used indentation and scratch methods using diamond tips, as well as cavitation tests. Scanning electron microscopy was used to interpret the results. For the correct understanding the layer systems have to be characterized sufficiently. The most important parameters in the given context are mechanical parameters as hardness and modulus as well as the sign and extend of the intrinsic stresses. Nanoindentation on a small angle cross section (SACS) was used yielding depth profiles of hardness and modulus of the observed systems. Curvature tests and focused ion beam combined with digital image correlation (FIB-DIC) were used to evaluate the intrinsic stresses. The microstructures of the adhesion layer system have been analyzed via transmission electron microscopy.

Keywords
ta-C
adhesion
annealing