Mechanical and tribological properties of nanostructured Carbon:Nickel nanocomposite films

Matthias Krause\textsuperscript{1}, Tim Kunze\textsuperscript{2}, Arndt Mücklich\textsuperscript{3}, Monika Fritzsch\textsuperscript{e}, Robert Wenisch\textsuperscript{3}, Sibylle Gemming\textsuperscript{3}, Gintautas Abrasonis\textsuperscript{3}

\textsuperscript{1}TU Dresden, Inst. für Festkörperphysik, Dresden, Germany \textsuperscript{2}TU Dresden, Theoretische Chemie, Dresden, Germany \textsuperscript{3}Helmholtz-Zentrum Dresden-Rossendorf, Dresden, Germany

matthias.krause@hzdr.de

The mechanical and tribological properties of nanostructured carbon:nickel films on silicon substrates are investigated using a multi-scale experimental and theoretical approach. The C:Ni nanostructures comprising either tilted columns or three-dimensionally self-organized nanopatterns are grown by ion-beam assisted deposition (IBAD). Complex layer architectures were obtained by sequential deposition by rotating the substrate in relation to the assisting ion beam after each deposition step. Atomic composition of the films was determined by ion beam analysis. The phase structure of carbon was analyzed by Raman spectroscopy, that of nickel by X-ray diffraction. The microstructure of the films was determined by high resolution transmission electron microscopy. The films show good adhesion as probed by scratch tests. The film hardness is on the order of 20 GPa, and the elastic modulus is at about 200 GPa. Friction coefficients on the order of 0.1 are found for oscillating wear conditions under ambient conditions. Atomistic computer simulations were applied to assist the experimental findings. Dry and liquid contacts are considered. The simulation shows a complex behaviour for the carbon-carbon interaction, e.g. resulting in the formation of a tribo-layer.

Acknowledgements: Funding by the European Union, ECEMP-Project D1, "Nanoskalige Funktionsschichten auf Kohlenstoffbasis", Projektnummer 13857 / 2379, is gratefully acknowledged. We thank Andrea Scholz (HZDR) for X-ray diffraction measurements and Angela Schneider (HZDR) for the mechanical and tribological measurements.

Keywords
nanocomposites
tribological coatings
carbon-based films