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PEEM analysis of the pin-on-disc weartrack of carbon/boron nitride nanometric multilayers

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A series of multilayer thin films composed of nanometric hexagonal carbon and boron nitride sublayers was grown on silicon substrates by ion beam assisted deposition (IBAD), following the method described elsewhere [1]. The period of the multilayers was varied between 3 and 40 nm in the whole series of samples. Carbon was deposited always with c-axis perpendicular to the substrate surface while BN was deposited in both, parallel and perpendicular orientations depending on the sample.
On these multilayered films, erosion pin-on-disc experiments were performed to create a measureable weartrack where only a few of the topmost sublayers are exposed to the environment. In this way, layers with nanometric thickness appear as micrometric and nanometric bands along the sliding direction in the wear track. The spectroscopic analysis of these compositional features in the weartrack constitutes a perfect playground to evaluate the microscopy and spectroscopy capabilities of PEEM in a real Materials Science problem.
After PEEM analysis, several interesting conclusions were obtained, which are briefly discussed as follows. The multilayered stacking is confirmed by observation of terraces of pure BN and carbon phases. The spectral features of B(1s) edge within one sample varies from an almost perfect hexagonal structure (already observed by TEM [2] for some multilayers), to a distorted hexagonal structure with a big amount of vacancy defects and, finally to the formation of metallic borides and/or borates [3]. This structural/compositional evolution is attributed to the tribochemical interaction with the Cr-steel ball during the mechanical test. It was found too, that Fe reacts selectively with boron while Cr does with carbon during formation of the tribolayer. Evolution on the formation of the tribolayer from metal Fe transfer, to formation of Fe borides is also discussed.
A detailed study based on comparison of compositional PEEM images and local XANES spectra extracted from the stacking of PEEM data is presented.

References

[1] I. Jiménez, R. Torres, I. Caretti, R. Gago, and J. M. Albella, "A review of monolithic and multilayer coatings within the boron-carbon-nitrogen system by ion beam assisted deposition,"J. Mat. Res., vol. 27, no. 5, pp. 743–764, 2012.

[2] R. Torres, I. Caretti, V. Serin, N. Brun, G. Radnóczic, and I. Jiménez, "Reversed texture in nanometric carbon/boron nitride multilayers,"Carbon., vol. 74, pp. 374–378, 2014.

[3] D. Fofanov, "Synthesis, characterization and physical properties of metal borides. (Doctoral Thesis).," Hamburg, 2006.

Caption (s) - Add figures as attached files (2 fig. max)

Figure 1: pi* B(1s) map of the weartrack of a C/BN multilayer with 40 nm period and the set of spectra obtained from several positions along a cross-line of the sample.

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