Microstructural origins defining the slip-rolling resistance of Zr(C,N) coating systems

I. Dörfel, H. Rooch, W. Österle, Ch.-A. Manier and M. Woydt

BAM - Federal Institute for Materials Research and Testing, Unter den Eichen 87, 12205 Berlin, Germany

ilona.doerfel@bam.de
Keywords: coatings, wear protection, microstructure, EFTEM

Beside the needs for cost reduction in mechanical applications the ecology is another driving force for materials science. Therefore working on materials brought in contact by adding coatings represents a possibility to replace toxic additives. Additionnaly, an improvement of the load carrying ability of steels can be expected.

The protective or wear-resistant properties of coatings of transition metal nitrides on diverse substrates are well known. Especially ZrN coated tools show enhanced wear resistance under sliding. Here we focus on novel Zr-based coatings deposited on substrates of steel “Cronidur®30” (X 30 CrMoN 15 1) as protection against rolling wear.

The deposition method is based on an arc procedure (cathodic arc evaporation).Tests of slip-rolling resistance of coated discs were performed versus uncoated steel counterparts. For this purpose, an Amsler-type twin disc tribometer (Fig.1) was used with different lubricants containing no or only low amount of additives. Differences in lifetime were obvious between the deposited batches of coatings. As reason of this behavior, different microstructures of the coatings were presumed.

From the tested sequence of samples two were selected for the electron microscopic investigations: sample 1 withstood 10 million cycles whilst sample 2 from another batch failed rather rapidly after 388 000 cycles.

In order to identify the microstructural origins of this significant different slip-rolling resistance, a comprehensive TEM study was undertaken.

The ferromagnetic properties of the Cronidur®30 substrate can cause problems during the electron microscopic investigations, even losing the sample in the worst case. Therefore the preparations of the TEM lamellae were done by the focused ion beam technique (Strata™ 200xP, FEI) in combination with an in-situ lift-out method (Kleindiek Nanotechnik).

The TEM/STEM investigations were carried out using a JEM-2200FS (JEOL) equipped with FEG, Omega-type energy filter, HAADF detector and EDX system (JED-2300, JEOL).

The coatings of both samples show polycrystalline, columnar growth and consist of a mixture of Zr(C,N) (cubic) and $Zr_3(C,N)_4$ (orthorhombic), this could be demonstrated by electron diffraction studies (SAD and NBD). Both phases can co-exist, Zr(C,N) is the stable phase of the ZrN-ZrC system, which forms substitutional solid solutions. Zr_3N_4 is a metastable phase and is formed at increasing N_2 partial pressure. It is softer than ZrN [1,2].

While the composition of both samples did not basically differ, further characterizations revealed markedly differences in their microstructure. These differences are the major factors engendering the high resistance variations during slip-rolling tests.

The detailed microstructural features of both samples will be compared in this contribution.

1. Z. Zhiguo, L. Tianwei, X. Jun, D. Xinlu, D. Chuang, Surface & Coatings Technology **200** (2006) p4918.
2. A. Frafiel, M.H. Staia, J. Munoz-Saldana, E.S. Puchi-cabrere, C. Cortes-Escobedo, L. Cota, Surface & Coatings Technology **202** (2008) p3653.
3. The financial supports of the German Research Foundation (DFG, project # Wo 521-6/1) and the Federal Ministry of education and Research (BMBF) within the project OTRISKO are gratefully acknowledged.

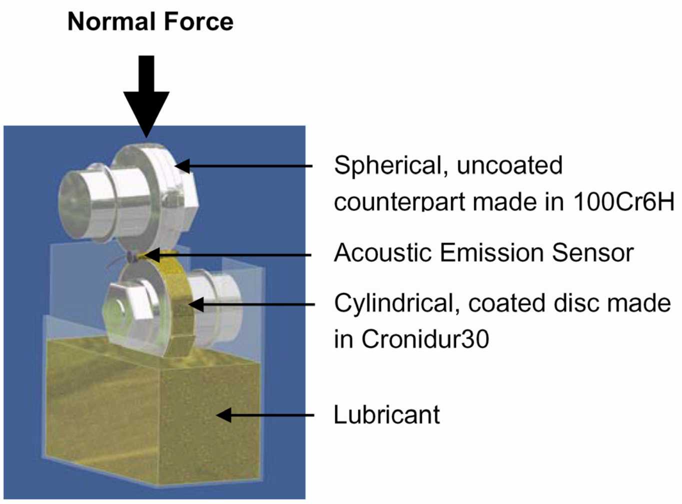

Figure 1. Scheme of the Amsler-tribometer

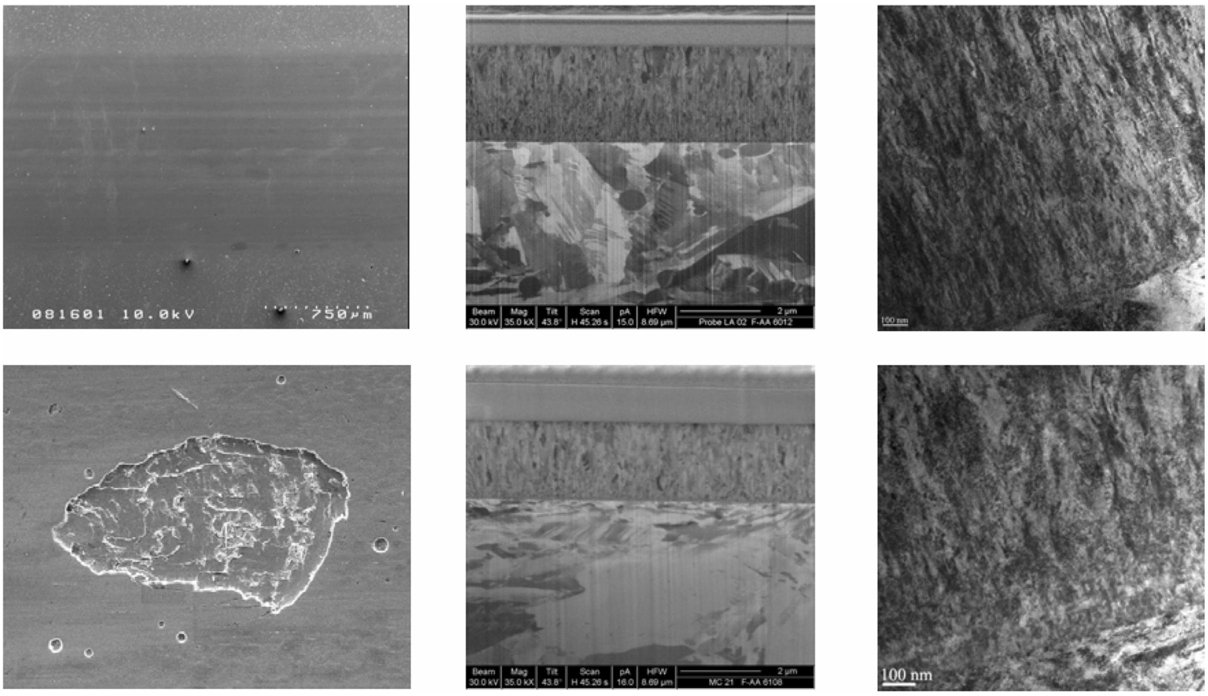

Figure 2. From left to right, SEM imaging of the surface, FIB cross section view, TEM lamella overview of the slip-rolling resistant coating (up) and of the poor slip-rolling resistant coating (down).

DOI: 10.3217/978-3-85125-062-6-528 , © Verlag der TU Graz 2009