









scratch track borders occurs. At 50 N an adhesive failure of the coating is visible.

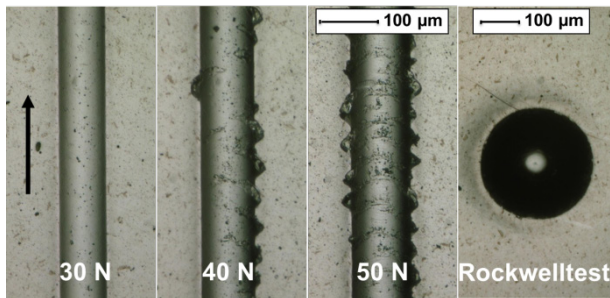


Figure 8: Scratch tracks at different loads and rockwelltest of the (Cr,Al)N coating (S6).

Considering the results in Table 1, the (Cr,Al)N coating exhibits the ideal critical loads on the X155CrMoV12 substrate with the variation of the following parameters in the mf argon ion etching: a duration of 60 min, a voltage of 650 V and a Ar pressure of 250 mPa. This pre-treatment will be used for the future studies on the further development of the (Cr,Al)N coating.

All Rockwell indentations exhibit adhesion classes between HF 1 and HF 3 regarding the classification by VDI guideline 3198 and these are all considered as acceptable. It can be said, that the HF classes of the coatings with Cr ion etching pre-treatment are lower comparing to the samples pre-treated with mf gas etching. But one of the aspects of the Cr ion etching treatment by HPPMS technology is the possibility of metal ion implantation into the surface which can lead to improvement of bonding force between the coating and the substrate surface [20]. In order to investigate this effect, an uncoated X155CrMoV12 specimen was sheltered in one half to prevent any treatment and the other half was Cr etched with the same parameters as by sample 19 (HPPMS Cr ion etching with HPPMS bias and offset configuration). Afterwards, the transition zone on the surface was analyzed by EDX line-scan, see Fig. 9. Existence of Cr on the etched surface is proven. Also SEM cross section fractions confirmed this observation, showing a thin Cr top-layer with a thickness of about 200 nm, see Fig. 10.

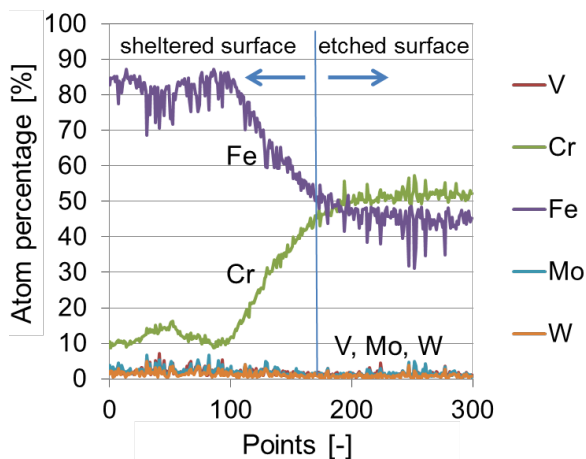


Figure 9: EDX line-scan of the sheltered and etched surface.

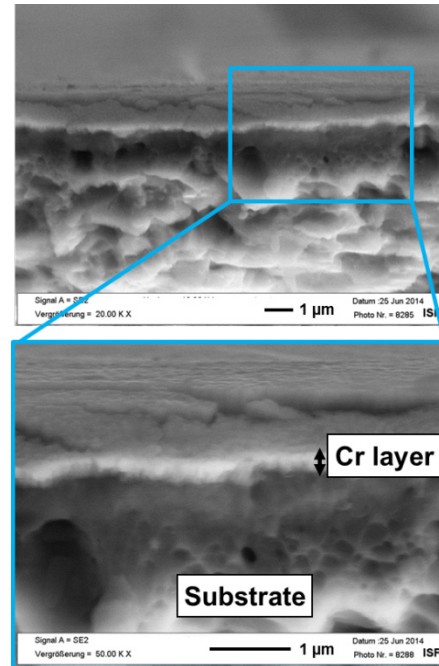


Figure 10: SEM cross section fracture of the etched surface.

#### 4 Conclusion and outlook

The absence of lubricants in dry metal forming significantly contributes to waste reduction in manufacturing processes and to the goal of a lubricant-free factory. However, the avoidance of lubricant usage goes along with the requirement that the dry tribological system or coating has to withstand the increased tribological loads. In this contribution a plasma etching process is developed for the (Cr,Al)N PVD tool coating to ensure a sufficient adhesion strength on the tool material.

Since the results in this study only give a first impression of a very recent research, there remain topics to finish in the future. Firstly, (Cr,Al)N development by means of HPPMS technology will be completed. After that, the self-lubricating disulfides will be embedded into the (Cr,Al)N matrices. Application oriented wear tests using the Pin-On-Disc (IOT) and a novel Pin-On-Cylinder tribometer (WZL) will be performed to analyze the friction behavior which will constitute an important extension of this work. Also, the advances in surface structures on workpieces will be investigated to provide friction reducing surfaces in dry metal forming by experimental studies of surface structures by WZL in order to identify friction and, thus, tool load reducing surfaces compared with non-structured workpieces. Synthesized, these two approaches from two institutions will achieve a lubricant free cold forging.

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