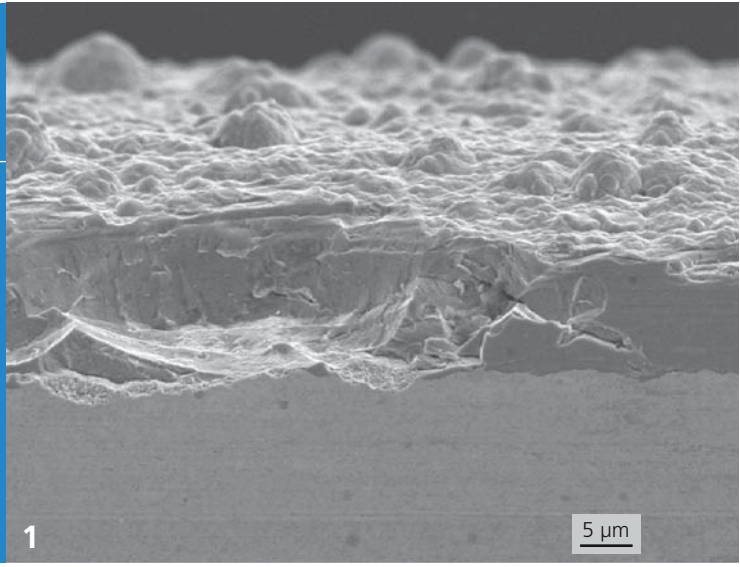


1

HIGHLY RESILIENT HARD COATINGS WITH HIGH SURFACE QUALITY

THE TASK

Thin wear-protection coatings for tools and components based on hard metal nitrides (e. g. TiN, AlTiN, CrN) are often used in industry. Typical techniques for the fabrication of such coatings up to approx. 10 µm thickness are PVD and CVD processes.

The fabrication of thicker coatings (>> 10 µm) faces a problem due to the increasing coating roughness. During Arc-PVD processes, for example, microscopically small particles act as an origin point of growing defect structures eventually leading to surface roughness. Furthermore, in nearly all thin-film processes, spontaneous disturbances emerge in the growing crystal structure, which lead to extended defect structures with increasing deposition time (see Fig. 1). The coating can then no longer fulfill its wear-minimizing function.

Fraunhofer IWS Dresden has therefore set itself the task of developing a coating technology that:

- allows the lowest possible surface roughness for layer thicknesses >>10 µm,
- ensures high efficiency in the coating process to produce thicker layers in a more reasonable timeframe.

OUR SOLUTION

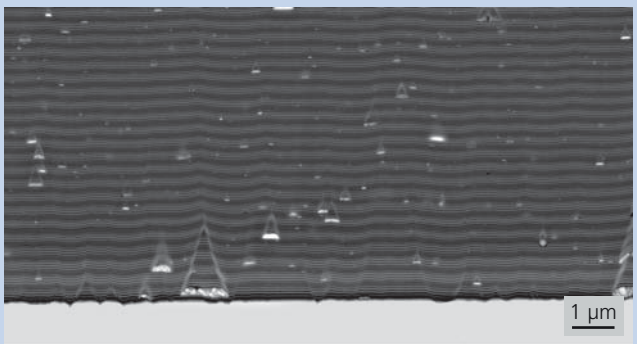
An important condition for the production of thick layers with sufficiently smooth surfaces is the suppression of the growth of defect structures. There are various approaches to achieve this, which are used singularly or in combination.

One possibility is the deposition of many layers with single-layer thicknesses in the nanometer range. With the appropriate combination of materials, the growth of defect structures on the interfaces of the single layers is interrupted. Existing defects thus become embedded in the desired layer structure and do not disrupt their function (see Fig. 2).

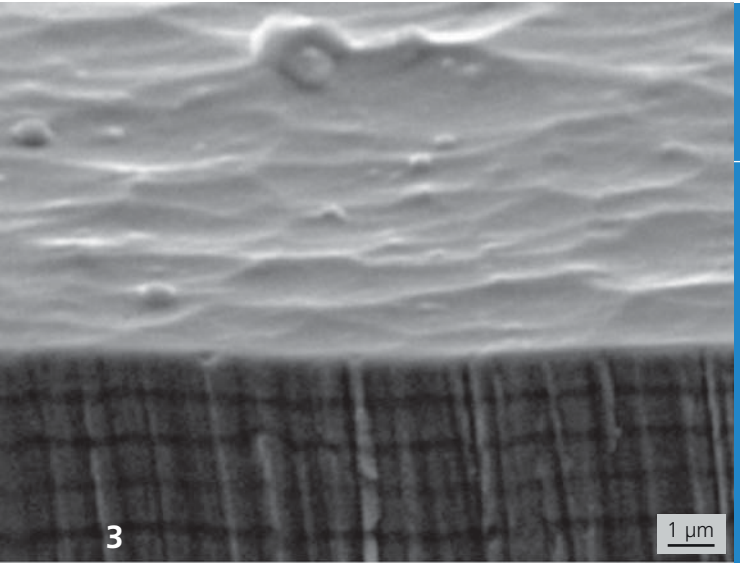
Another approach to defect suppression is the use of highly ionized plasmas. During the coating process the high-energy plasma particles remove unwanted roughness peaks. With the arc process, for example, the plasma excitation can be increased through appropriate parameter selection.

Optical emissions spectra were recorded during the vacuum arc process. In the standard process for depositing an AlCrN coating, singly and doubly charged Al and Cr ions are detectable. In the more highly charged process, the quantity of ions rose significantly and a trend of multiply charged ions is noticeable.

Cross section of a multilayer hard coating with neutralized defect structures



2

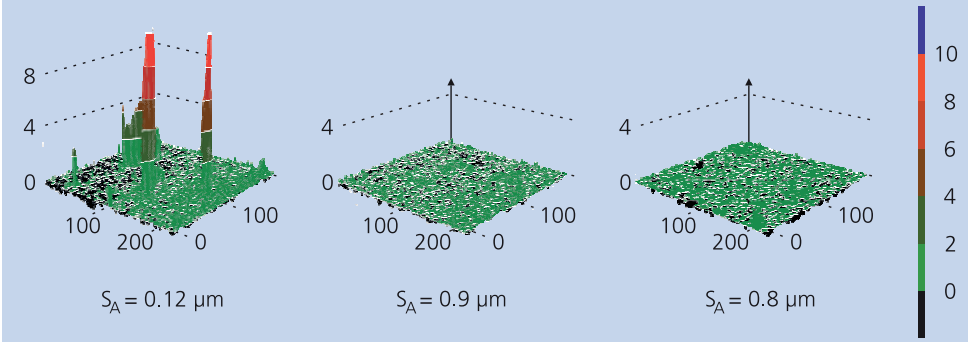


3

RESULTS

Figure 2 shows the cross section of a multilayer hard coating that was produced with increased plasma excitation. The inhomogeneities in the layer volumes, which are attributable to the deposit of microscopically small particles during the coating process, are clearly visible. These will be covered and flattened in the course of the layer growth until eventually a once again flat surface is formed.

Comparison of topographies: Standard process (a), standard process with mechanical smoothing (b), and process with increased plasma excitation and in-situ smoothing (c) in µm



4a **4b** **4c**

SEM pictures (Fig. 3) and topographical analyses (Fig. 4) of coated surfaces show that with the combination of multilayers and high ionization, smooth coating surfaces are producible. With standard processes one would have to polish the coating after the deposition process to achieve similar results.

Forging tools with smooth hard coating

5

For the coating of tools for prototype and forming processes, for example those which are shown in Figure 5, this technological approach constitutes a meaningful perspective. In extreme conditions, the coatings must meet highest demands in terms of surface quality. This is usually only achieved by coating processes in combination with sophisticated post-processing. The method presented can contribute to a substantial minimization of effort in the coating of such tools.

1 Defect-rich coating, produced with the arc process

3 Defect-poor multilayer coating, produced with highly ionized plasma

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