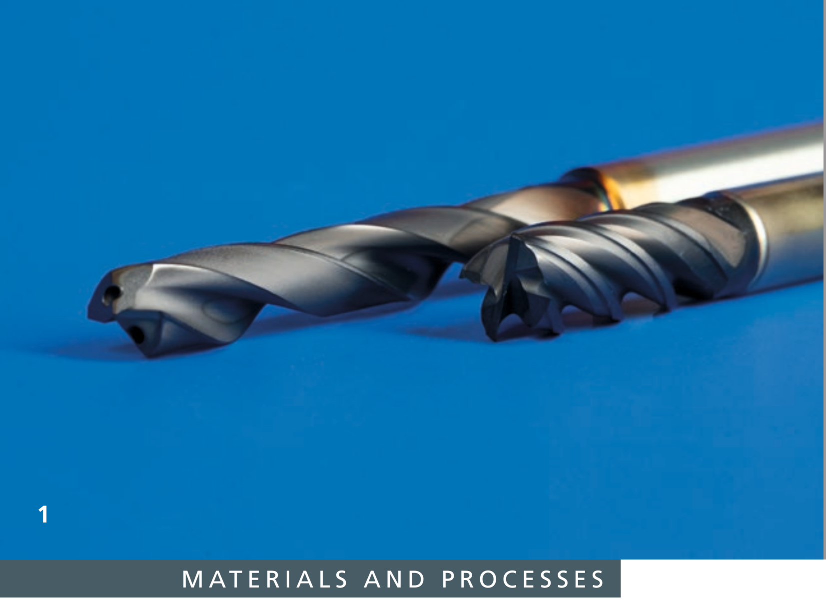

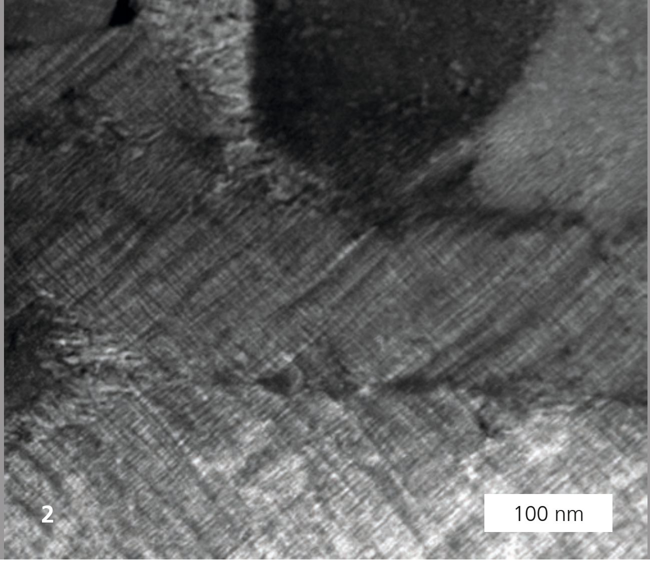

WEAR-REDUCING ALUMINUM-RICH CVD-TiAlN LAYERS

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Steadily increasing demands on cutting tools resulting from increasing requirements for high-speed and dry machining, as well as the machining of high-strength and difficult-to-machine materials, are the driving force behind the development of new and more efficient wear protection layers. Temperatures of over 1000 °C are reached at the cutting edge and especially on the rake face at high cutting speeds. Therefore, modern wear protection layers must offer a good resistance to oxidation as well as a chemical inertness to the workpiece material in addition to the required high hardness. Over the past few years, $Ti_{1-x}Al_xN$ with cubic structure has become an important standard layer for wear protection. Aluminum-rich $Ti_{1-x}Al_xN$ layers, which mainly contain the hard cubic phase, offer significantly better wear resistance than $Ti_{1-x}Al_xN$ layers with lower aluminum contents. $Ti_{1-x}Al_xN$ layers with a predominantly cubic structure and high aluminum contents of $x > 0.65$ are currently not achievable with conventional physical vapor deposition (PVD) processes, such as magnetron sputtering or the arc process. With thermal chemical vapor deposition (CVD), cubic $Ti_{1-x}Al_xN$ with $x > 0.65$ can be deposited on hardmetal substrates. However, it is not yet known why the cubic phase stabilizes in the CVD process with very high aluminum contents. That is why Fraunhofer IKTS is pursuing the goal of investigating the mechanisms of CVD deposition in more depth, with the aim of using the findings for further improvement of the layer structure. A horizontal vacuum hot-wall reactor with separate introduction of the reactive gases was used for the CVD process. The reactants $TiCl_4$, $AlCl_3$ and NH_3 as well as Ar, H_2 and N_2 were used as starting materials for the $Ti_{1-x}Al_xN$ layers. The deposition parameters of temperature (700 to 900 °C), pressure (5 to 60 mbar) as well as gas composition were varied. The formation of soft, wurzitic AlN in the deposited cubic $Ti_{1-x}Al_xN$ layers could be minimized through the specific adjustment of the NH_3/H_2 ratio. This resulted in an increase of the indentation hardness from 25 GPa to 32 GPa. The microstructure shows the formation of large Al-rich cubic $Ti_{1-x}Al_xN$ columnar crystallites, which grow along the <110>-direction. Under favorable deposition conditions, the formation of nanolamellar structures (so-called fishbone structure, Figure 2) within the aluminum-rich cubic $Ti_{1-x}Al_xN$ crystals can be adjusted in a targeted manner. These columnar crystallites are characterized by periodically arranged Al- and Ti-rich cubic $Ti_{1-x}Al_xN$ domains, which are observed by scanning TEM with EDS and EELS. The developed aluminum-rich cubic $Ti_{1-x}Al_xN$ CVD layers have excellent wear resistance, which results from their superior hardness, intrinsic residual compressive stress and good oxidation resistance.

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1 CVD-TiAlN coated milling and drilling tool.

2 Fishbone-like microstructure of a $Ti_{0.19}Al_{0.81}N$ hard layer deposited by CVD (TEM image, Source: TU BA Freiberg).

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