Investigation of CVD TiCN/$Ti_{1-x}Al_xN$ multilayer coatings by advanced electron microscopy

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Indexable inserts are widely used in metal cutting applications like turning, milling, parting, and grooving. Cemented carbide is often used as substrate material, mainly containing tungsten carbide and a cobalt binder phase [1]. To increase cost efficiency and productivity as well as process reliability, hard coatings are deposited on the substrates using chemical vapor deposition (CVD) [2]. Ti(C,N) is widely used as a coating material due to its high hardness and outstanding wear resistance. [3] Another material widely used is TiAlN, which combines high hardness with good oxidation resistance. Recent development has made it possible to use CVD to deposit TiAlN coatings with a Al/Al+Ti ratio of around 0.9, which is accompanied by extensive hardening effect.

To increase efficiency metal cutting applications requires ever increasing cutting speeds (>250m.min-^{1}), which induces high temperatures at the interface tool - chip material [4]. One way to increase the performance of hard coatings is to combine layers of different materials, creating multilayered coatings. However, the adhesion between the layers in a multilayer coating is a critical point when it comes to how well the coating functions for metal cutting applications. Thus, it is of importance to investigate which factors that influences the adhesion between different materials used in hard coatings.

In this work, a hard CVD coating, consisting of one TiCN layer and one $Ti_{1-x}Al_xN$ layer, has been grown on cemented carbide substrate pre-coated with TiN. A range of different of electron microscopy and spectroscopy techniques were used to carefully examine the structure and chemical composition of the multilayer coating at different scales, including grain size, texture and atomic scale. Aberration corrected scanning transmission electron microscopy (STEM) and electron energy loss spectroscopy (EELS) analysis reveal the presence of interfacial dislocations, twins, stacking faults (Figure 1) and the formation of new interfacial phases (Figure 2).

Reference:

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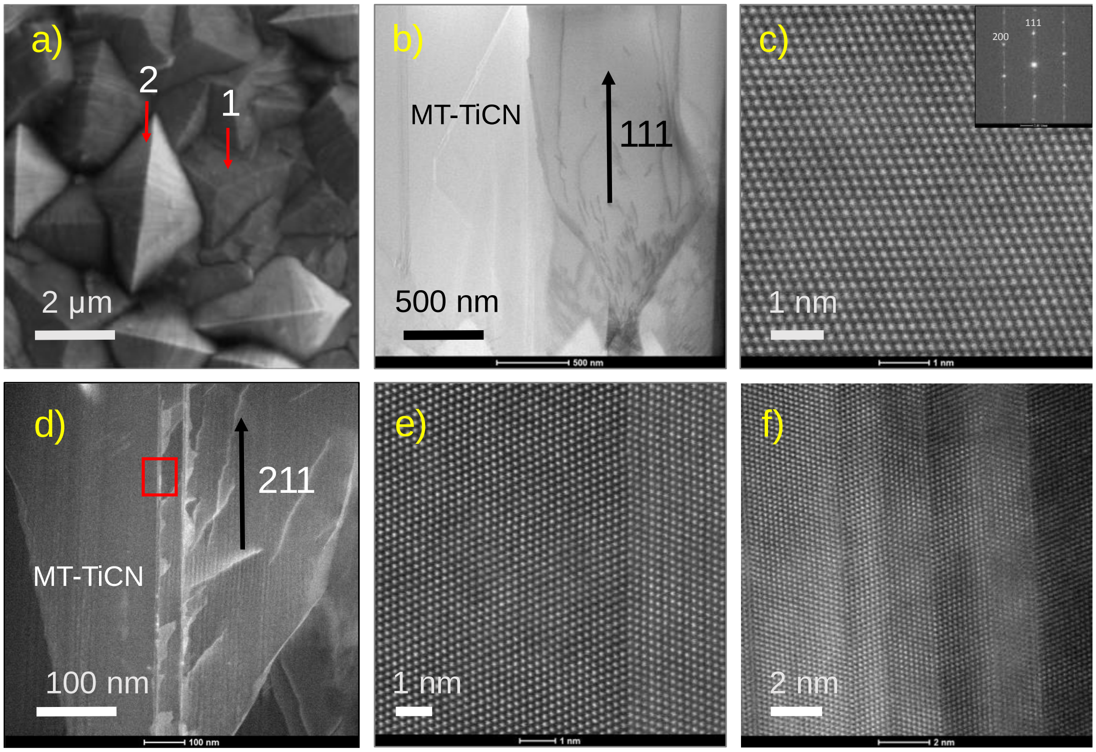

Figure 1: a) SEM image of the top surface of the coating showing two different morphology of MT-TiCN: pyramid and melon respectively 1 and 2. b) and c) HAADF-STEM images of the cross section of the pyramid grain showing the growth along 111 axis.

d), e), and f) HAADF-STEM images of the melon grain showing growth along 211 and several twins and dislocations.

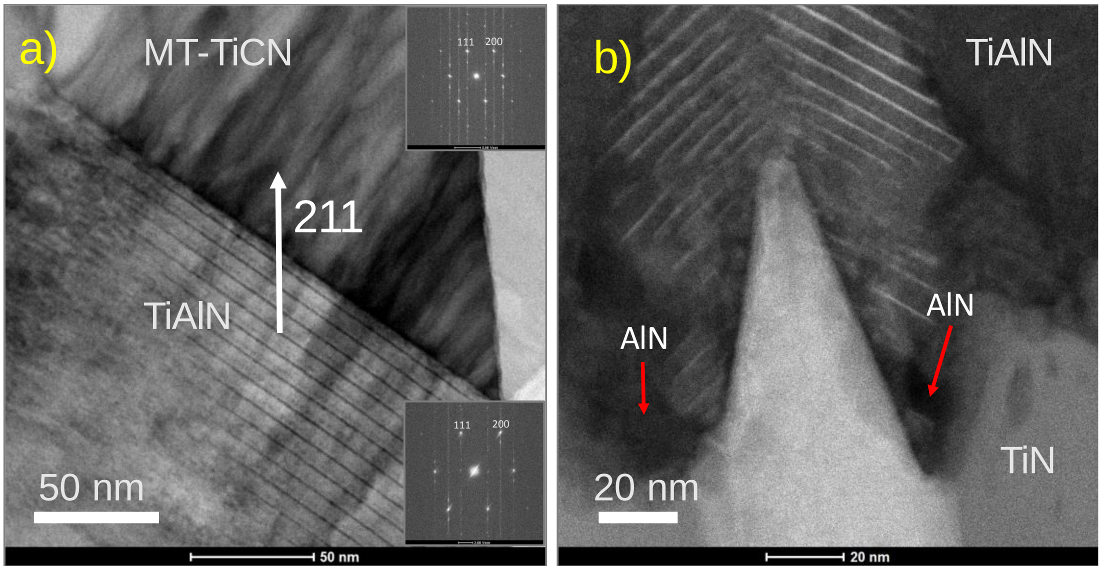

Figure 2: a) BF-STEM image of the interface between TiAlN and MT-TiCN showing epitaxy growth along 211 axis and several dislocations in MT-TiCN (dark area). b) HAADF-STEM image of the interface between TiN and TiAlN showing the presence of h-AlN interfacial layer.