Local microstructure variations in CVD TiAlN hard coatings

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TiN with NaCl crystal structure has been widely used in hard coatings for cutting tool materials. By replacing the Ti atoms partially with Al, cubic TiAlN is formed which has attracted significant attention in the latest years due to its outstanding oxidation and wear resistances. Originally physical vapour deposition (PVD) was used for the deposition of the TiAlN coatings, however in recent years technical development has made it possible to deposit TiAlN coatings using chemical vapour deposition (CVD). However, the microstructure of CVD TiAlN coatings is very sensitive to growth conditions in the furnace and much research remains to fully understand what parameters that influence the growth of CVD TiAlN coatings.

In this work, a CVD TiAlN coating was grown on a cemented carbide substrate pre-coated with TiN. The setup of the coating experiment was designed with respect to the reactive gas flow such that the corner of the coated piece was in the vicinity of the area of a specific gas velocity. Several lamellas were prepared from different positions on the sample by using a focused ion beam (FIB) system, the first lamella from the edge corner and the last from a position 600 micron away from the corner, the rest of the lamellas were prepared in between these points, see Figure 1(b). The lift-outs were further studied by transmission electron microscopy (TEM). Local variations in microstructure and chemical composition were investigated by (scanning) transmission electron microscopy (S)TEM, energy dispersive X-ray analysis (EDX), and electron energy loss spectroscopy (EELS).

It was found that microstructure varies along the investigated direction, with an increasingly disordered microstructure towards the edge of the insert, see Figure 1(c) - (h), and that this disorder is connected to variations in chemical composition. At the 600 micron position it was also found that the composition varied periodically in most grains as a double 'fish-bone' structure, different from the single-layered 'fish-bone' structure reported in reference [1], with the grains growing along a 111 texture with 001 faces. As shown by the STEM HAADF micrograph in Figure 2, the 'fish-bone' structure contains three types of layers with different Al/Ti contents. All regions exhibit the fcc structure, which is the desired phase for hard coatings.

Reference:

[1] J. Zalesak, *et al*, Peculiarity of self-assembled cubic nanolamellae in the TiN/AlN system: Epitaxial self-stabilization by element deficiency/excess, Acta Mater 131 (2017) 391-399.

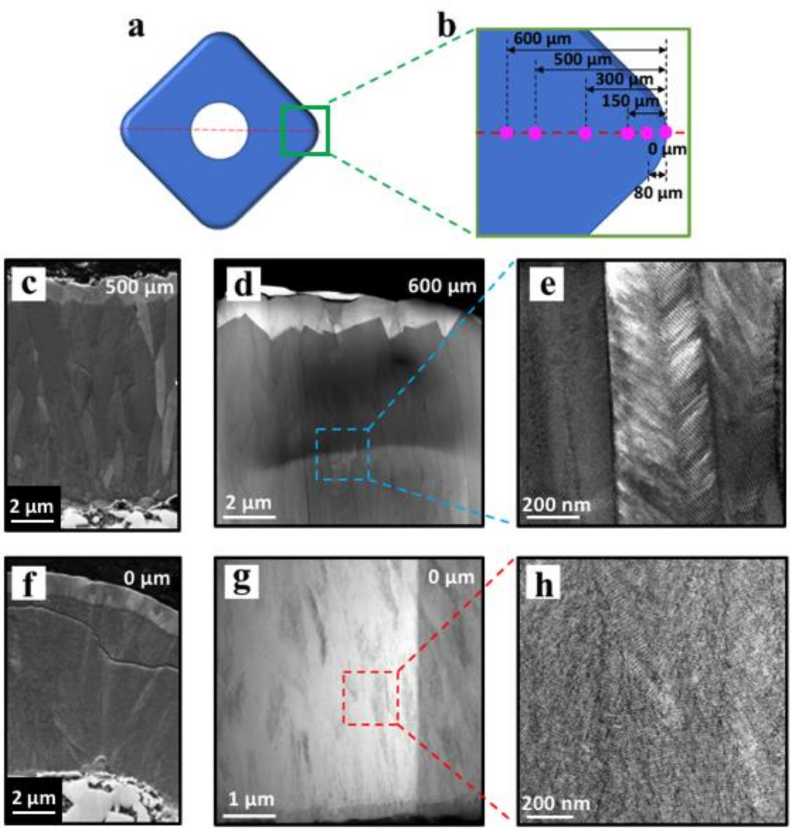

Figure 1: (a) Schematics of the CVD coated cutting tool. (b) Schematics of the area where the lift-out samples, the first from the edge corner (illustrated as 0 micron position) and the last from a position 600 micron away from it, are prepared. (c) and (f) SEM images of cross sections at 0 micron and 500 micron positions. (d), (e), (g) and (h) HAADF images of lift-out samples taken from 0 micron and 600 micron positions.

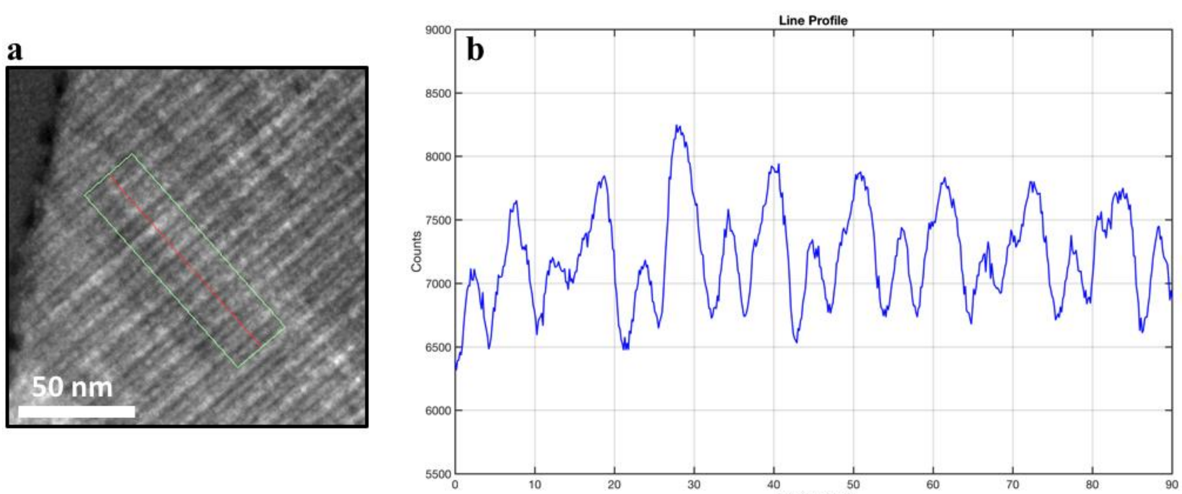

Figure 2. (a) STEM image of the double "fish-bone" structure. (b) Line profile of the double 'fish-bone' structure.