PO2029

Thermal stability, hardness and fracture toughness of ZrAlN/TiN and ZrAlN/ZrN multilayers

Yu-Hsiang Chen[1], Lina Rogstro□m[1], Joan Josep Roa[2], Jianqiang Zhu[1], Isabella Schramm[1], Lars Johnson[3], Marc Anglada[2], Magnus Odén[1]

[1]Linköping University, Linköping, Sweden [2]Universitat Politècnica de Catalunya, Barcelona, Spain [3]Sandvik Coromant, Stockholm, Sweden

yuhch@ifm.liu.se

Wear resistance at high temperatures is crucial for hard coatings as the operating temperature for applications like metal machining may reach 1000 °C. Previously, low Al content cubic-ZrAlN/TiN multilayer has shown promising high temperature properties, where the hardness is retained after annealing at 1100 °C for 2 h. Increasing the Al-content, a wurtzite ZrAlN phase with higher thermal stability is obtained. Here, we incorporate multilayer structures with this ZrAlN phase to further enhance the strength and thermal stability of coatings.
High Al-content (~75%) ZrAlN/TiN and ZrAlN/ZrN (5nm/10nm) multilayers with ~5 μm total thickness were deposited by arc evaporation and their thermal stability and mechanical properties were characterized. Out-diffusion of Zr into TiN sublayers and formation of a Ti(Zr)N phase during annealing is found by atom probe tomography microscopy and confirmed by transmission electron microscopy. The strain evolution was determined by wide angle x-ray scattering in situ during annealing. The formation of the Ti(Zr)N phase results in retained compressive strain in the ZrAlN/TiN film, in contrast to ZrAlN/ZrN multilayers where the strain is fully relax during annealing. The hardness of ZrAlN/TiN multilayers is 32 GPa even after annealing at 1100 °C for 2 h while the hardness of ZrAlN/ZrN decreases. Better fracture toughness of ZrAlN/TiN than ZrAlN/ZrN multilayers under annealed state is also revealed by scratch and cube corner indentation experiments followed by electron microscopy characterization. Cross-sections of the scratched coatings reveal higher resistance for crack propagation in ZrAlN/TiN multilayers. The critical load for the first crack observed in the vicinity of the cube corner indentation, is again higher for ZrAlN/TiN multilayers. The results show that ZrAlN/TiN multilayers exhibit high strength between sub-layers due to the secondary phase Ti(Zr)N, which retains the stress field resulting in increased mechanical properties in terms of hardness and fracture toughness.

Keywords
Zirconium aluminum nitride
Multilayers coatings
Mechanical properties