New PVD Coatings for Metal forming Applications

In an increasingly competitive manufacturing sector there is a requirement to reduce costs and become more efficient. This can be achieved by gaining more life out of tools and reducing down time. For this reason hard coatings are having increasing importance in metal forging sectors by prolonging die life, reducing manufacturing down time and improving the surface quality of the forged parts. PVD hard coatings, such as TiN, have been introduced since the mid 1980's in a number of cold forming and extrusion processes, where the wear rate of dies had been reduced satisfying the demands at that time. However, as forging technology has advanced so too has the technology used to deposit such coatings and thus today's coatings have vastly increased hardness, wear resistance and frictional properties. The BCFG workshop was an ideal forum to discuss these advancements in PVD technology and new coating architectures that have been developed by the unique collaboration of Sheffield Hallam University and Bodycote-SHU Coatings Ltd. The academic and industry driven research has resulted in tailor made PVD solutions to industrially important surface engineering issues.

During the workshop an overview of PVD technology was shown from the early years of Arc and Magnetron Sputtering deposition techniques, producing for example TiN, through to the state-of-the-art ABS technology (Arc Bond Sputtering) currently used at Bodycote-SHU coatings to produce denser, smoother functional coatings. The ABS system combines both unbalanced magnetron mode (UBM) and steered cathodic arc (CA) mode. This combination in a single unit (see Fig. 1) allows the engineering of a metallurgically engineered interface by using the cathodic arc discharge to generate metal ions to atomically etch and implant metal atoms into the tools surface prior to deposition of the coating by UBM. This metal ion etching of the tool has been recognised as a powerful tool in enhancing the coating - substrate adhesion, and thus, the life of the tool.

Figure 1 - Hauzer HTC 1000 – ABS advanced PVD coating machine

Using the aforementioned technology the deposition of a nanoscale multilayer (superlattice) coatings featuring up to four or more elements i.e. TiAlCrYN (Supercote 11), CrN/NbN (Supercote 40), TiAlN/VN (Supercote 33) and C/Cr (Supercote 60) have become a reality. Superlattice coatings featuring repeating ultrathin layers of coatings e.g. CrN/NbN, where the bi-layer thickness is in the range of 3 - 4nm and a 4μm coating can contain in excess of 2000 individual layers are proving especially interesting in many applications. With correct performance tailored material selection and the right bi-layer period/thickness new properties not found for the individual layer materials are created, these include increased hardness, toughness and wear resistance. Further advancements were further detailed, such as the Duplex process, in which plasma nitriding followed by superlattice coating deposition are performed in one machine.

Practical examples of these new coatings in cold, hot and aluminium forming / casting were shown. Supercote 11 (TiAlCrYN) and Supercote 40 (CrN/NbN superlattice) coatings have been applied to various form tools, for example for hot forging operations. Figure 2(a) shows an extrusion die and an as-produced forged product (a chisel bit for a pneumatic digger). The die material was H13, extruding at 1100^{o}C under a load of 300 tonnes. The application of Supercote 11 with its extremely high oxidation resistance (950^{o}C) and low friction top coat extended the die life by 3 times without the need for the application of carbon lubricant. A further example is shown in Figure 2 (b), which illustrates a die used for precision hot forging of turbine blades for aero-engines. These dies were used to "stamp-out" components from billets of inconel 718 material preheated to ~1100^{o}C at a load of 500 tonnes. In the as-machined and uncoated condition this die produced 700 components, however, after subsequent re-machining (with Supercote 11 coated milling tools) and application of Supercote 11 this die went onto to produce an additional 1600 components thereby completing the production requirement (2.3 times life than that of the uncoated die) and on inspection it was seen that the coated die only exhibited minor wear and was still serviceable for more production. Supercote 40 (CrN/NbN) has shown excellent results in blanking and drawing of steel sheet (where a 30 times improvement in die life was observed), cold drawing of stainless steel and in cemented carbide matrix dies for forming steel ball bearings. A further application in which, Supercote 11 is the coating of choice is for aluminium die casting operations, it has been shown to out-perform WCC, TiN, TiCN, TiAlN, CrC and others due to its high oxidation and diffusion resistance and its extremely smooth low friction top coat, which prevents material adherence.

Figure 2 A chisel bit for a pneumatic digger and extrusion die

Figure 2b Die used for precision hot forging of turbine blades for aero-engines

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