SECA
Surface Engineering Coating Association

End Users Guidelines to PVD Thin Film Coating Properties and Applications

The purpose of this section is to show a general range of properties typical of a specific coating chemistry in order to allow end users some comparative basis and begin the process of determining what coating may be best suited for a particular application. The listing of properties for a particular coating chemistry is at times not an easy task:

- Testing of a 1 to say 20 micron thick coating is not an easy task compared to measurement of bulk material properties. There are a variety of test methods and they may be subject to interpretation and variation.
- Exact coating properties are determined by the specific technology used, and a number of varying technologies resulting in a range of coating microstructures and adhesion properties are used to obtain similar chemistries.
- Coatings may contain a number of layers of varying chemistry (various stoichiometric ratios) and small additions of various elements to achieve certain properties.
- At times, it may be better to view coatings as having a certain range of properties as opposed to one specific value (unless you are involved with only one technology run very consistently).

General Statements:

Titanium Nitride (TiN) is considered the first commercial PVD thin film coating, developed in the late 70's and introduced during the early 80's in the North American market. It is still considered a good general purpose / universal coating for a wide range of tooling (cutting, forming and molding), decorative and component applications and represents on the order of 40-50% of all PVD coating applications.

Properties:

Hardness (HV 0.05) - 2,600 +/-300
Oxidation Stability (1 hour in air) - 550C-600C (1,000-1,100 F)

Titanium Carbonitride (TiCN) has higher hardness due to the inclusion of carbon in the metal nitride lattice, but at the expense of oxidation resistance. This is a good example where coating chemistry changes may represent a trade off in properties. In general, the higher the hardness, the greater the wear resistance. Since TiCN has better abrasion resistance, but lower oxidation resistance, it performs well in lower temperature (lower cutting speeds) on machining of heat treatable or hardened materials. In addition, TiCN has been used in a variety of forming applications.

Properties:

Hardness (HV 0.05) - 3,500 +/- 500
Oxidation Stability (1 hour in air) - 400C (750F)

Titanium Aluminum Nitride (TiAlN) / Aluminum Titanium Nitride (AlTiN) coatings are available in a wide range of chemistries (stoichiometric ratios) and structures (single and multi-layer) and have increased hardness and, above all, higher oxidation resistance due to the addition of aluminum to the structure. These enhanced properties make TiAlN or AlTiN type coatings excellent in machining abrasive materials, e.g., grey cast iron or cast Al-Si alloys at increased speeds (higher temperature conditions). These types of coatings have also been useful in semi-dry or dry machining applications as well as high temperature molding (eg., aluminum die casting operations).

Properties:

Hardness (HV 0.05) - 3,400 +/- 200
Oxidation Stability (1 hour in air) - 800-900C (1,470-1,650)

Chromium Nitride (CrN) is characterized by lower compressive stresses in the coating structure permitting thicker coatings. CrN coatings can exhibit good corrosion resistance and are considered a good alternative to chrome plating (twice as hard, free of cracks, and applied in an environmentally friendly manner). In addition, CrN has good oxidation stability and has been found to be very effective in machining copper-based alloys and stamping/forming operations.

Properties:

Hardness (HV 0.05) - 1,850 +/- 100
Oxidation Stability (1 hour in air) - 700C (1,290F)

Carbon-based Coatings (CVD Polycrystalline Diamond, Diamond-like Carbon (DLC), Amorphous Diamond (AD), etc. are now used in a variety of tooling and component applications. Low coefficient of friction and a wide range of hardness, give these coatings a wide range of applications in cutting, forming, molding and precision components.

Duplex Coating Systems have combined both different coating chemistries or different processes in order to achieve benefits in specific applications. For instance, PVD technology may be combined with ion nitriding in order to improve the nature of the substrate (hardness) for better support of the thin PVD layer, or a "hard" and "soft" coating combination may be beneficial in low lubrication machining operations.

Tribosystem Considerations It should be remembered in all coating applications, that the coating of a tool or component does not simply lower the wear rate, but that the whole "tribosystem" is changed. It is the responsibility of the end user and the job coater to review all possible changes and effects in the application.

Proper substrate preparation, eg. heat treatment, grinding, EDMing, deburring, polishing and cleaning, etc. are critical to he quality of the coating and the resulting tool or component performance.

SECA - "helping to link coating technology innovation and development to commercial implementation"