

PHYSICAL VAPOUR DECOMPOSITION METHOD**Mümin ŞAHİN***Trakya University Faculty of Eng. and Arch. Dept. Mech. Eng. 22180, Edirne-Turkey***Cenk MISIRLI***Trakya University Faculty of Eng. and Arch.
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Dept. Mech. Eng. 22180, Edirne-Turkey***Abstract**

PVD (Physical Vapour Decomposition) method is based on separating atoms from surfaces and accumulating (atomic or ionic) them to sub-material surface to be coated, by evaporating or sloping materials under vacuum. Coating material, in PVD method, is transmitted to surface in atomic, molecular or ionic form, obtaining it not chemically but physically from solid, liquid and gas source. Chemical reactions can exist on main material surface too colder than CVD coating (50-500 °C); however such a reaction formation is no necessary. It is more interesting that PVD operation is performed in relatively lower temperatures. In addition, after completion of coating micro structure and properties of main material are not affected. PVD Method is carried out by three methods called as evaporating, dispersion and ionic coating. In the presented study, it was given the knowledge about the Physical Vapour Decomposition method and the developments in its applications.

Keywords: PVD method.**INTRODUCTION**

Wearing on equipments limits usage physical life of machine parts. The manufacture numbers in recent years and shutdown periods due to wearing on automatisisation. Thus, wear preventing is gaining more and more importance economically. New Tool steels types are being developed within course of working on them over the years and the ways to increase physical life of these steels are being researched. Important developments, by ultra-hard thin films originated on tool surface, have been achieved in recent years. Features of nitride, carbide, and oxides used in these coatings as like hardness, lubricant, and abrasion resistance have been known for long times. The fact that these materials are brittle and fragile hinders usage from full materials and so their prices are very high.

At the end of 1950's, fast-running benches were produced within the aim of increasing production. After the production of these benches, technicians encountered with this question 'How life span, especially for hard

metal tools, can be increased'. As a result of research conducted, by increasing life span of tools in question, to minimize rundown time of machines, tools were started to be coated with hard laminations as like TiN and TiC, developing a technique under the name of CVD (Chemical Vapour Deposition) in 1960's. Although this was suitable for hard metals, it did not give good results in heat-treated steel tools. That is to say, it has not been possible to coat steel tools losing its hardness between the temperatures of 200 and 400°C. As the coating which is applied by a method named as CVD (Chemical Vapour Deposition) only can be possible in values of 1000-2000°C, this caused loss of hardness on heat-treated and sensitively processed steel tools (cold manufacturing steels, hot manufacturing steels and high speed steels) and changing in their dimensions.

While looking for an alternative coating technique, a method PVD (Physical Vapour Deposition) named as ION-PLATING was developed in America in the late 1960's. This method enabled heat-treated tool steels to be

coated between the temperatures of 180 and 600°C. However, coating technologically, in the sense that this technique is passing from laboratory course to industrial processing, was implemented by ION-BOND method in 1970's. After these years, coatings applied particularly to cutting tools have been developed. Whilst developing coatings as like TiAlN ve TiCN for higher speed and dry-applicable workbenches, CrN-typed coatings were developed for forming moulds (Injection, extrusion, deep drawing, plastering etc.). Great developments were experienced in high efficiency, low cost and high quality materials production in industry by modernizations and new coating techniques [1-12].

PVD METHOD (PHYSICAL VAPOUR DEPOSITION METHOD)

Physical Vapor Deposition (PVD) is a process to produce a metal vapor that can be deposited on electrically conductive materials as a thin highly adhered pure metal or alloy coating. The process is carried out in a vacuum chamber at high vacuum (10⁻⁶ torr) using a cathodic arc source.

Single or multi-layer coatings can be applied during the same process cycle. Additionally the metal vapor can be reacted with various gases to deposit Oxides, Nitrides, Carbides or Carbonitrides.

PVD Equipment and PVD Process

Choosing the right equipment was the single most important decision in guaranteeing the success of the operation. Our first system was built in the USA and operates a patented Low Temperature Arc Vapor Deposition (LTAVD) process. This leading vacuum system manufacturer has 22 US patents and over 25 years of experience.

The second PVD system built in Europe utilizes the cathodic arc principles combined with multiple targets and has the ability to deposit different metals during the same coating cycle. Additionally this PVD chamber has an efficient handling system for quick transfer and loading of parts between cycles. Both manufacturers are recognized for producing the most sophisticated high volume decorative coaters in the world. This highly

sophisticated equipment provides precise process control and easy to use computer graphic interface. These systems have the largest coating zones currently available in a batch coater so we can coat large complex shapes or large volumes of small components. The flexibility to coat a variety of substrate materials is extremely advantageous, particularly heat sensitive materials like plastic or zinc. A photo of PVD method is given in Figure 1.



Fig. 1. PVD Equipment

The parts to be coated are first cleaned. The cleaning process varies depending on the level of quality from the electroplater, substrate material and geometry. The parts are loaded into the vacuum chamber on custom fixtures designed to optimize the chamber load size and insure coating uniformity.

The vacuum chamber is evacuated to 10⁻⁶ torr (high vacuum) to remove any contaminants in the system. The vacuum chamber is backfilled with an inert gas argon and ionized, resulting in a glow discharge (plasma). This is the gas cleaning stage and prepares the parts for the initial metal deposition.

A high current, low voltage arc is initiated on the target (solid material used for deposition). The metal is evaporated and instantaneously ionized. These metal ions are accelerated at high energies into the vacuum through an inert gas or reactive gas and subsequently deposited on the part. The basic properties of the metal being evaporated (target) remain unchanged during the metal

deposition cycle. Changing the volume of gas and type of gas during the reactive deposition cycle changes the nature of the coating producing ceramics like carbides, nitrides or oxides. For instance, zirconium nitride (ZrN) is a hard, yellow-gold colored coating with exceptional wear and corrosion resistance. Zirconium nitride has become predominant in the plumbing and door hardware industry as a lifetime brass color. Introducing measured amounts of nitrogen into the chamber during the zirconium deposition cycle produces zirconium nitride.

Chromium nitride is produced in much the same way. Simply by adding an additional gas such as acetylene (C₂H₂), you can create chromium carbonitride. This is a gray to black color. The use and properties of the various coatings available from PVD coatings can, in many cases, be tailored to the individual customer application [11].

Advantages of PVD Coatings

- Covered material reaches very high surface hardness levels (3000 – 4000 HV about 85 – 90 HRC) without loss of its resistance and its abrasive resistance increases.

- As coating penetrates to main material, it adheres to perfectly material and it is inseparable as result of being exposed to thermal expansion or trauma.

- As thermal transmittance of coating is on low level, it can move up to high speed (approximately 30 % speed and penetration are obtained.). For this reason, work item surface becomes smooth.

- Coefficient of friction on cutting edge decreases, lubricity level increases and edge accumulations don't exist in the course of cutting.

- As coating thickness is between 2 – 15 µm, tolerances of covered items are unchanged. Tools can be used without necessity of an additional operation.

- As its colour is different from tools, tools wearing can be easily definable.

Application Areas of PVD Method

Coatings with PVD method are used commonly as coating is performed in different temperature ranges, compound of part to be

coated is not important and complex parts can be coated uniformly.

Application areas of coatings performed with this method can be categorized for application purposes as follows [12];

- Decorative coatings

Decorative coatings in industry are used commonly. These coatings are used in toy industry, automobile industry, souvenir production, white wares, pencil, watches, and glasses frames. These coatings are proffered as they are not only useful for decorative purposes but also in functional. For example, they are proffered because TiN coating for watches and glasses frames makes them golden and provides wearing resistance for wares. Automobiles having low weight are requested due to energy bottleneck in automobile industry. Because of this, light plastic parts are used instead of heavy ones and these parts are coated by PVD method.

- Optical functional coatings

These are used in laser optics (reflection and transmission), home and automobile mirrors, glasses and lenses, big projects, camera lens and filters. In addition, transparent and hard coatings are carried out by this method. For example, transparent coatings as like helium oxide, tin oxide, are used in liquid crystal display applications.

- Electrical functional coatings

This method is used in semiconductors, hybrid circuits, capacitors, magnetic environments, superconductor coatings, contact parts and sun batteries.

Electronic circuit elements as like resistance and capacitor are performed on placket by this coating method. The most important reasons why electronic industry prefers coating existed by PVD method are as follows;

1. Very thin and correct coatings are produced,
2. Coating may be performed preferred surface,
3. multilayered coatings may be performed.

- Mechanical functional coatings

This is used in jet engine turbines, cutting tools, mould pieces and for military purpose.

Mechanical properties developed with TiN, CrN, Ti(CN), (TiAl)N coatings for cutting edges increase performance of these parts. Thus, these edges function in more rapid rotation speeds, have longer usage time, and therefore increase workload rate.

- Chemical functional coatings

These coatings are used in production of corrosion-resistant parts, gas turbine motors, cutting blades and vessels.

It is indicated that coatings produced by this method in cutting edges, forming moulds, blades and vessels increase corrosion resistance. The important point here is that corrosion resistance can be provided with a correct and nonporous coating structure.

There are various application areas where electrolytic coating is available as like enabling electrolytic coating and coating conductive materials by splashing method.

- Potential applications

Coating obtained by PVD method in laboratory course and being developed is available and there are similar application areas as follows;

- * Materials having high resistance and hardness,

- * Coatings having low cost and high corrosion resistance,

- * Very hard coating (Diamondlike coatings),

- * Coating new super-conductive materials,

- * Newly-developed optic and electronic materials,

- * Coatings in amorphous structure,

- * Production of fine-grained dust material which is metal, ceramics, alloy or mixture of these,

- * Very diverse and fine grained composite materials having resistance and hardness.

Examples belonging to application areas of PVD method are given in Figures 2, 3, 4 and 5.



Fig. 2. TiN Coated Parts [4]



Fig. 3. TiAlN Coated Parts [4]



Fig. 4. Ti(C,N) Coated Parts [4]



Fig. 5. CrN Coated Parts [4]

CONCLUSIONS

As mentioned above, PVD method finds increasingly worldwide as manufacturing method to coat machine elements. The method is suitably used almost in every industry. It is obvious that more and more usage of PVD method as brave will be useful for both companies and people.

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