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Filtered Plasma Deposition and MEVVA Ion Implantation

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Abstract

The modification of metal surface by ion implantation with MEVVA ion implanter and thin film deposition with filtered vacuum arc plasma device is introduced in this paper. The combination of ion implantation and thin film deposition is proved as a better method to improve properties of metal surface.

Keywords : MEVVA, Filtered Plasma Deposition

1. Introduction

The energetic plasma is widely used in surface modification for both metal and non-metal materials. The MEVVA, i.e. metal vapor vacuum arc technology is a new method in providing low temperature plasma with very high flux in vacuum [1,2]. It can produce plasma at almost 100 % ionization efficiency from all metal materials and some conducting non-metal materials, such as graphite and impure silicon.

MEVVA device can be designed as an ideal ion source for a high current ion implanter, a good plasma source for low temperature surface modification or a perfect plasma source for thin metal or ceramic films such as oxides, nitrides and carbides. Since the MEVVA ion source is operated in a pulsed mode, the beam current, the deposition speed and other parameters can be easily and precisely controlled. With a magnetic field duct - a macroparticle filter for removing neutral and large particle, the magnetic filtered MEVVA thin film deposition device (FPD) has been proved as an ideal tool in making nanometer thin films, such as magnetic thin films and magnetic multilayers.

Several MEVVA sources can be installed on a vacuum chamber to form a multipurpose surface modification machine, such as the relatively new and emerging technology: the Metal Plasma Immersion Ion Implantation and Deposition (MePIIID). It can provide combined ion implantation, plasma surface modification and thin film deposition in a very flexible way.

In this article, the surface modification of metal and non-metal materials by MEVVA related technology in Beijing Normal University is reviewed. The details of the MEVVA based ion implanter and thin film deposition system developed in BNU can be found elsewhere [2,3].

2. Metal Surface Modification

The metal surface can be modified by ion implantation, film deposition or combined implantation/deposition processes.

Metal ion implantation can be easily processed with MEVVA ion source. Ions with acceleration potential of 50 - 80 KV are most often used. The thickness of modified metal layer is in a range of few hundred nanometers that is greater than the corresponding ion range. The new nanophases are formed in this modified layer. For example, TEM shows Filar phases of FeTi

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and $FeTi_2$ in a Ti implanted steel. These phases have diameter of 10 - 30 nm and length of 150 - 320 nm. The density of these dispersed phases is around 1×10^{11} cm^{-2}. The formation of these new nanophases can explain the significant improvement of wear and corrosion resistance in the implanted layer [4]. In dual Ti + C implantation of steel, Auger analysis revealed atomic ration of 25% titanium and 43% carbon in the implanted layer. These concentrations are greatly exceeding the saturation solubility of titanium and carbon in steel. The XRD pattern of Mo + C implanted steel indicates the formation of complex phases of Mo_2C, MoC, FeMo, Fe_2MoC and FeC [3]. Other multi-ion-implantations, such as C + W [5], C + Ti + C [6], V + C [3] have been also carried out and proved as a very efficient way to enhance wear and corrosion resistance.

The filtered plasma deposition can produce very thin and uniform films at nanometer scale. Since the neutral and large particles produced from cathode arc are filtered, the plasma is relatively pure and uniform at the depositing surface. Thus, films with very high quality at few nano to few hundred nanometers thickness can be obtained.

The combination of MEVVA implantation and FPD has been proved as a very efficient way to produce very dense and tight thin films. The pre-implantation can significantly improve the smoothness of the surface and enhance the adhesion of film on the base materials. For example, in some cases, DLC films are difficult to adhere on some metal alloy surfaces. The pre-implantation can enhance the film adhesion coefficient drastically.

3. Non-Metal Surface Modification

Surfaces of non-metal materials can also be modified by ion implantation and FDP.

One example is implantation of C, Si and Cu on polyethylene terephthalane (PET) [7]. The changes of surface morphology were observed by AFM. Surfaces became smoother after implantation. The roughness has been reduced from 25 nm to 5 nm with C and Si implantation. Therefore, the C and Si implantation on PET can improve the smoothness and wear resistance of the materials. With Cu implantation, dispersed nanometer Cu conducting islands were formed on PET when dose was higher than 2×10^{17} $/cm^2$. These islands produce conducting layers on PET, similar to silver implantation.

The carbon implantation on PET can also enhance surface hardness. XPS indicate formation of DLC-like compound within the implanted surface. This technique may find application in making protection film in hard disk drives [8].

Another example is W deposition on PET by FPD. Ions of tungsten with acceleration potential of 12 KV were implanted first on PET to improve the surface condition. Then the deposition by FPD on PET makes a tungsten film. When this film is thicker than 60 nm, the PET becomes conducting and much wear resistant. For example, with 70 nm of tungsten films deposited, the hardness was increased to 500 %, and modulus of elasticity was increased to 180% in comparison with naked PET [7].

4. Conclusions

Ion implantation and filtered plasma deposition are proved as very useful techniques in surface modification of both metal and non-metal materials. The combination of mono or multi ion implantation, in addition with the magnetic filtered thin film deposition with MEVVA plasma source is a very flexible and efficient way in surface technology.

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