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Characteristics of Silver films deposited on the surface of PET fabric

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Abstract:PET(polyester) plain woven fabric deposited with nano-structured silver thin film was prepared by RF (radio frequency) magnetron sputtering at room temperature. The effect of different sputtering technical parameters on the morphology and particle diameters of the nano-structured silver thin film was characterized by AFM(atomic force microscope)and the conductivities of silver thin films were also analyzed under different sputtering technical parameters. The results indicated that the nanoparticles size of sliver thin films increased with higher sputtering power, the conductivity of sliver thin films was first decreased and then markedly enhanced; The nanoparticles size of sliver thin films decreased with higher gas pressure, the conductivity was markedly decreased; The nanoparticles size of sliver thin films increased with longer sputtering time, the conductivity was markedly enhanced, The best conductivity was achieved at the sputtering time of 15min.

Introduction

Nano-silver is a new functional materials, small particle size, large effective area, has a surface effect, quantum effects and other unique properties, an extremely excellent performance in electrics, optics and catalysis and many other aspects, and it has broad application in chemical, textile, medicine, optical, electronic and other industries[1].

Nano-silver film is an ideal functional material as the substrate of textile materials that can be used to develop UV-shielding materials, fiber solar cells, medical antibacterial material etc， preparation of silver film at present is mainly CVD, sputtering, electroless method and electroplating method[2,3].In the article, silver films were prepared by the radio frequency(RF) magnetron sputtering at room temperature. The sputtering process parameters, such as gas pressure, sputtering power, sputtering time and others have an important impact on film performances[4], studied the effect of sputtering process parameters on the surface morphology, conductive properties of silver films .

Experimental section

Experimental materials

The substrate was polyester (PET) plain fabric, warp density of 332 root/ 10 cm, weft density of 206 root/ 10 cm. The substrate were cut into 6cm × 6cm samples, placed in acetone solution and washed 30minwith ultrasonic washer on the acetone solution, to remove the organic solvents ,dust and other impurities on the fabric surface , and then dried in 40-45℃ drying oven, then placed in desiccators in abeyance.

The target was high purity Ag (purity was 99.99%, diameter is 50 mm)and sputtering gas was argon gas for industrial use, purity of 99.99%.

Sample preparation

The equipment of silver thin film deposited was multifunctional high vacuum magnetron sputtering (Shenyang Juzhi Technology Co., Ltd.) .High-frequency electric field to make argonionized, the cations of ionization bombard the silver target with high speed under the control of the magnetic field, the silver atoms on the target are sputtered out,silver films deposited on the substrate. The distance between the target and substrate was 80 mm, in order to reduce the pollution of gas impurities on the material, improve the performance of films, first vacuum chamber pumped to 5.0×10^{-4}Pa and then pumped into the high-purity argon (99.99%) to a certain pressure, flow rate was 20 mL / min. In order to make silver particles sputtered out not be uniformly attached to the substrate, keep sample holder at the rotatation of 20 r /min.

Performance characterization

The surface morphology was examined by atomic force microscopy (AFM). The AFM used in this study was CSPM 4000 scanning probe microscope test system provided by Benyuan Co., LTD.Scanning was carried out in contact mode and all samples were scanned at room temperature in the atmosphere. The scanning scope was set at a size of 5000nm×5000 nm, and the scanning frequency was set at 1.0 Hz.

Film sheet resistance with SX-1934 four-probe tester produced by Baishen Technology Co., Ltd (test conditions:temperature was 23℃, relative humidity was 65%), we measured in 10 different locations to get the average in order to eliminate the error caused by the uneven of fabric substrate.

Results and analysis

Effect of sputtering power on Ag films

Surface topography analysis

Nano-silver films were deposited on the polyester fabric under the conditions of pressure in vacuum chamber 0.6 Pa and sputtering time reached 10min.Fig.1 showed the AFM images of silver films prepared in the different sputtering power.

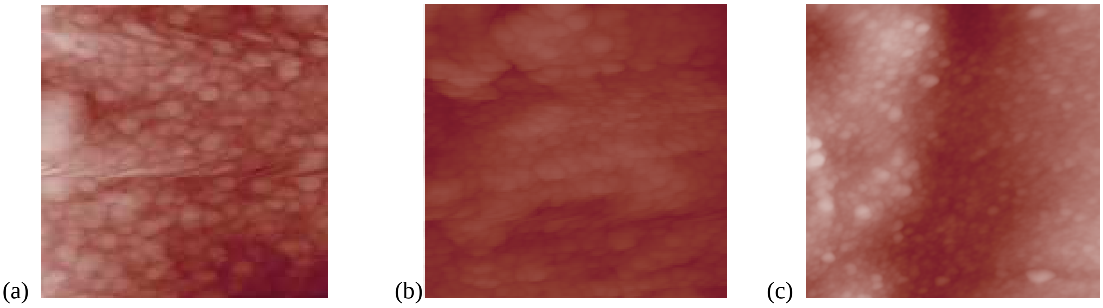

Fig.1 :AFM images of Ag thin films under different sputtering power: (a)80w;(b) 120w;(c)160w (Scanning scale is 5000nm×5000nm)

From Fig.1 a,it can be seen that silver particles uniformly covered the surface of substrates, the size of particles were regular, a small number of particles occured reunion in Fig.1b,the gap of particles were smaller,regular distribution in Fig.1c, it illuminated that the compactness of silver films was good.

The average diameters of silver particles deposited were respectively about 52.6nm, 57.2nm, 69.2nm by the analysis of atomic force microscope with a post-processing software .It showed particle diameter increased with sputtering power increasing. This is due to the increasing of sputtering power, the chance of collision between silver particles sputtered out of target surface and argonion increased , more silver particles were sputtered in unit time which reduced the migration rate of particles on the surface of thin films, resulted in larger particle [5,6].

Conductive properties

Fig. 2 showed the relationship of sputtering power and conductive properties of nano-silver films. The sheet resistance of films first increased and then decreased significantly with the increase of sputtering power from the figure,it described the conductivity of thin film first weakened and then enhanced obviously. Sheet resistance decreased more apparent when sputtering power were between 120w and 160w. It could be understood that silver particles sputtered out in unit time also increased with the increase of sputtering power, they constantly deposited and collided on the fiber surface, which make sputtering rate of particles also increased, when sputtering rate was lower , generated films were loose structure,it was difficult for electrons to pass through their barrier, the capability of the migration of electrons on the films was weaker, conductivity was also weaker, so the higher resistance value. When sputtering rate was higher, surface of films was more regular and denser, the negative influence of potential barrier to the conductivity of films reduced, sheet resistance value of the films was lower, so the stronger conductivity.

Fig.2: The relationship between Ag film sheet resistance and Sputtering power

Effect of sputtering pressure on Ag films

Surface topography analysis

Nano-silver films were prepared on the polyester fabric under the condition of sputtering power 120w and sputtering time was 10min. Fig.3 showed the change of silver films (the AFM images of silver films prepared under different gas pressure)

(a) (b) (c)

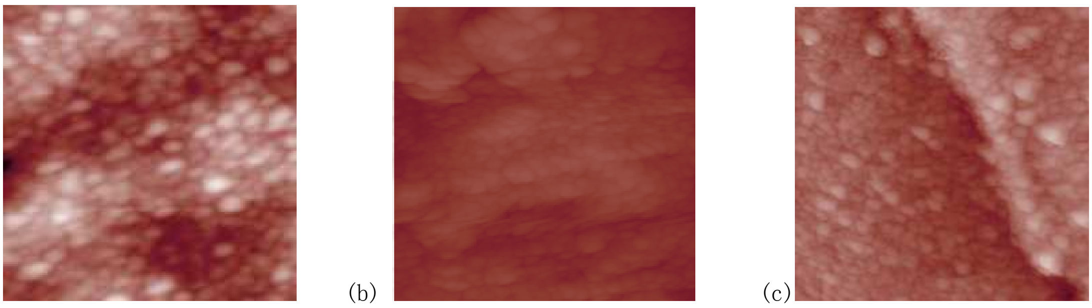

Fig.3:AFM images of Ag thin films under different gas pressure:(a)0.3pa;(b)0.6pa;(c)0.9pa (Scanning scale is 5000nm×5000nm)

The average diameters of silver particles deposited by the analysis of post-processing software,were respectively about of 58.1nm, 57.2 nm, 49.9nm in Fig.3, which showed the diameters of particles decreased with the increase of gas pressure; meanwhile, the uniformity and continuity of silver films decreased with the increase of gas pressure in vacuum chamber; it was mainly due to the increase of gas pressure, the opportunities on the collision of argon gas molecules and silver particles sputtered out increased, which make the free path of charged particles bombarding silver rake cut short, the kinetic energy of silver particles sputtered out reduced,which make it difficult to reach the surface of substrate, the diameters of silver particles deposited were also decreased in the same time, meanwhile the molecular on the surface of films diffused lower,restricted the growth, the surface became uneven and discontinuous.

Conductive properties

Fig.4 showed the relationship between gas pressure and conductive properties of nano-silver films. The film sheet resistance also increased with the increasing of argon pressure from the figure,which indicated the conductivity of films weakened significantly. When the gas pressure was more than 0.6Pa, sheet resistance increased more quickly, conductivity of the films also decreased rapidly, the opportunity of collision between energetic charged particles and argon gas molecules was increased with the increasing of gas pressure in vacuum,which caused free path of charged particles short, the kinetic energy of silver particles sputtered out also reduced, not easily deposited on the fiber surface, conductive performance of thin film reduced [7].

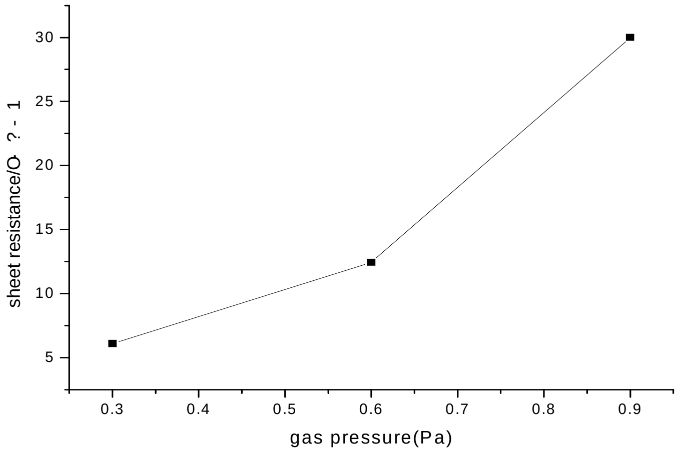

Fig.4:The relationship between Ag film sheet resistance and gas pressure

Effect of sputtering time on deposition Ag films

Surface topography analysis

Nano-silver films were respectively coated on the polyester fabric for 6min,10min,15 min when sputtering power reached 120w and sputtering pressure was 0.6 Pa.

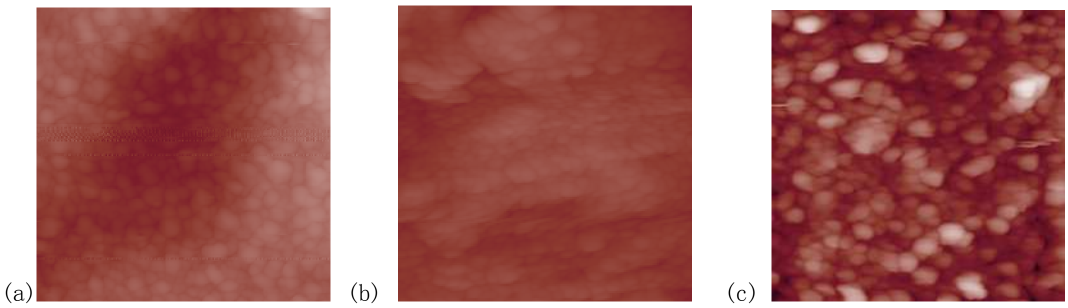

Fig.5: AFM images of Ag thin films under different sputtering time : (a)6min;(b)10min;(c)15min (Scanning scale is 5000nm×5000nm)

Silver films were made up of a number of small particles, uniform particle size, continuous distribution, but the fiber surface was not completely covered by the nano-silver particles,for small diameter about 49.2nm from the Fig.5a, the substrate was covered all right ,there was a small amount of nano-silver particles reunited on the film surface ,which formed a larger particle diameter about 57.2 nm in Fig.5b, the average diameter of silver particles increased to 70.6 nm in Fig.5c, larger difference in particle size and smaller gap,the density of film surface improved more significantly than Fig.5a and Fig.5b. It indicated the silver atoms sputtered out from the surface of target gradually increased with coating time extended, density of the atoms deposited on the surface of fiber increased,which reduced the gap of particles on the surface of substrates , so the uniformity and density of films were improved.

Conductive Properties

Fig.6 showed sheet resistance of films decreased and electrical conductivity gradually increased with the increasing of sputtering time.Nano-silver particles deposited on the surface of polyester fibers gradually increased with the extending of sputtering time and the rate of film growth was faster, the density and uniformity on the surface of films improved and the conductivity of films gradually increased. When sputtering time reached 15min,It could be found from the above AFM chart, the continuity and compactness of the films were best, the value of sheet resistance reached 3.5 Ω/ϒ, so the best conductive performance.

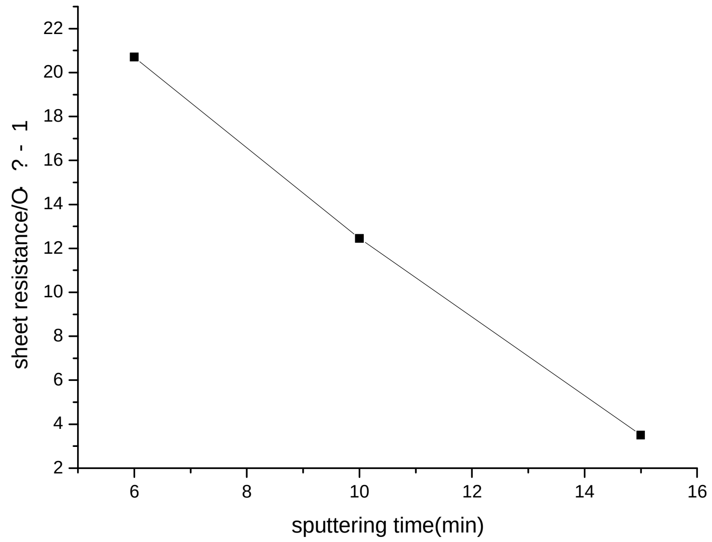

Fig.6: The relationship between Ag film sheet resistance and sputtering time

Conclusion

The article has studied the morphology and conductive performance of nano-silver films prepared on the polyester fabric by magnetron sputtering at room temperature.The surface morphology was also affected by the sputtering conditions, the conductive surface has such applications as anti-static, conductive shields and protective materials,which provides a new approach to the surface modification of textile materials.

References

[1] Synthesis,characterization,and optical properties of Zinc Oxide nanostructures[D] Shanghai: Shanghai Jiaotong, University ,2008:1-3

[2] Eun Gyeong Han, Eun Ae Kim, Kyung Wha Oh. Electromagnetic Interference Shielding Effectiveness of Electroless Cu_plated PET Fabrics [J]. Synthetic Metal, 2001 (123) :469-476.

[3] Kim MS, Kim HK, Byun SW, et al. PET Fabric / polypyrrole Composite with High Electrical Conductivity for EMI Shielding [J]. Synthetic Metals, 2002 (126) :233-239.

[4] Hong Jianhan, Wang Hongbo, Wei Qufu, et al. AFM analysis and conductivity of nano-structured silver film deposited by magnetron sputterin [J]. Journal of Textile Research,2006,27(9):14-17.

[5] Li XiuJie. AFM Analysis of ZnO thin films prepared by magnetron sputtering [J]. Management and Development of mechanism, 2003 (2) :15-16.

[6] Rizzo A, Taglienate MA, et al. Structure and Optical Properties of Silver Thin Films Deposited by RF Magnetron Sputtering [J]. Thin Solid Films,2001,396 (1) :29-35.

[7] Chen Wenxing, Du Lijuan, Yao Yuyuan, et al. Study on electromagnetic shielding fabric prepared by magnetron sputtering [J]. Vacuum Science and Technology, 2007,27 (3) :264-268.