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The Effect of Sputtering Power on Properties of Ni/SiO_2 Composite Film Optical Attenuation Slices

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Abstract. To increase properties of optical attenuation slices, vacuum magnetron sputtering method was used to prepare nanoscale Ni/SiO_2 optical attenuation slices with vacuum magnetron sputtering coating apparatus in this paper. The XRD, AFM, SEM and 722 spectrophotometer also were used to study the effect of sputtering power (300/400/600/1000/1200W) on structure and properties of optical attenuation slices. The results indicated that: film of (111) and (200)crystal orientation was obtained on Ni/SiO_2 substrate. Surface was also smooth, particle distribution was uniform and arrangement of particles were compact at 400W working power. Attenuation rate reached 0.52, properties improved.

Keywords: optical attenuation slice, magnetron sputtering, sputtering power

1 Introduction

Optical fiber communication was a weak power excitation behavior, if the transmittal optical power was greater than the the threshold power, it could cause distortion of the optical signal transmission, the errors of transmittal date, image distortion and other phenomena, so that they seriously affected the quality and effectiveness of fiber optical communication[1]. Optical attenuator[2-4] was becoming an important power management device of optical fiber communication networks, it was a optical passive device that was designed to reduce transmittal optical power in the waveguide, and limit the transmittal high power optical signal to below threshold. Coating method of magnetron sputtering as an advanced process method, its hybrid layer was made up with multilayer metal or metal oxide layer, it allowed the energy passing rate and energy reflectivity were regulated arbitrarily, with good effect in aesthetic appearance[5-8]. nickel/SiO_2 samples were prepared with magnetron sputtering technique in the vacuum condition, and focused on the effect of sputtering power to sample tissue structure and transmittance property.

2 Experimental

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In order to avoid the pollution caused by their own. SiO_2 glass substrates were washed and dried firstly. The metal Ni target was fixed on the electromagnetic target location, SiO_2 glass substrates were put into the specimen shelf. According to the experiment requirement to adjust the temperature, temperature was 25℃. The molecular pump, power taps and mechanical pump were started to pump base vacuum. Pure Ar as the working gas, the oxide layer and pollutants of the target surface were removed with pre sputtering of 10min and ion etching of 20min before deposition of Ni film. Sputtering power was opened to sputter, Ar+ ions were formed from Ar gas in high voltage current. Ni target was bombarded by Ar+, Ni atoms escaped and were deposited on the surface of the SiO_2 substrate. All power source were closed after reaction, cooling and sampling.

3 Results and Discussion

3.1 Effect of sputtering power on the film structure

Fig.3-1 represented XRD patterns of films with different sputtering pressure.

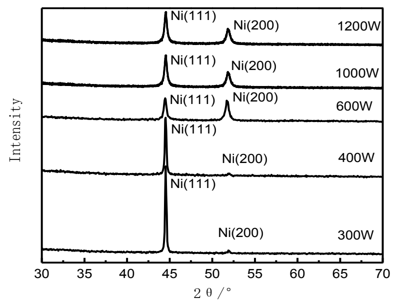


Fig.3-1. XRD patterns of films with different sputtering power

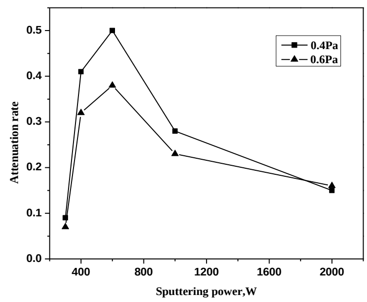
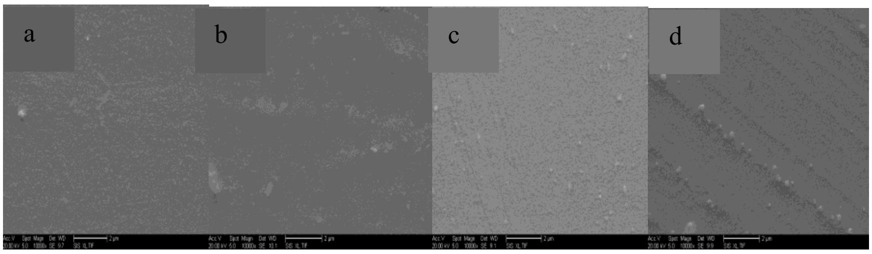


Fig.3-3. Attenuation rate of Ni film with different sputtering power

Figure3-1 showed two diffraction peaks of crystal face of Ni(111)and Ni(200), and the peak intensity of direction Ni(111) was maximum. Diffraction peak intensity curve of direction Ni(111) was more obvious when sputtering power was 300W, on the contrary, Ni(200) was not. With the increase of the sputtering power, Ni atoms were sequentially deposited on a glass substrate. When the sputtering power reached 400W, diffraction peak intensity of Ni(111) sharply increased, but Ni(200) had only little change. Diffraction peak intensity of Ni(111) decreased slightly when sputtering time reached 600W, while Ni(200) peak significantly enhanced, and closed to Ni(111). This indicated that, Ni film growth had a Ni(111) preferred orientation during the sputtering process, and Ni film grew with a preferred orientation on the Ni(200) simultaneously when the sputtering power to a certain extent[9].

3.2 Effect of sputtering power on micro structure and flatness

To study the effect of sputtering power on the surface morphology of the film in process of magnetron sputtering, similar to other process conditions in the experiments, the work pressure and sputtering time were 0.4 Pa and 10 min, respectively, surface morphologies of metal Ni film were tested under different sputtering powers. SEM micrographs were shown in figure 3-2.



a) 400W b) 600W c) 1000W d)2000W

Fig.3-2. SEM images of Ni film with different sputtering power

The membrane surface was smooth and compact with uniform particle distribution, small convex dome was hardly seen at 400 W in figure3-2a), Continuing to increase sputtering power to 600W, 1000 W or 2000 W, white convex dome and groove could be seen clearly in the membrane surface and the roughness of the surface was poor in figure 3-2b),c) and d).

Because of bombarding particles with smaller energy, surface diffusion of sediment particles played a leading role in the range of sputtering power. Filling cavities of the surface constantly led to smooth surface. When the sputtering power was beyond this range, temperature of the target material was increased as a result of too high sputtering yield . The target surface corrosion caused low utilization rate of target material. Increasing condensation nuclei of sputtering atoms in the substrate was caused by large sputtering power. While the energy of condensation nuclei was increased, larger stress was existed within membrane layer, which led to low adhesive force and uneven surface. Sputtering power was large to cause the phenomenon of ion implantation and lower deposition rate. Therefore, choosing appropriate sputtering power had an important influence on smoothness, compactness and uniform light attenuation of membrane layer. Glow discharge produced more Ar+, the collision frequency of nickel atoms and Ar+ were increased, the diffusion kinetic energy of nickel atoms in film surface was reduced at high power, so that grain crystal was larger, roughness was increased. This caused above [10].

3.3 Effect of sputtering power on transmittance

722 spectrophotometer was used to show transmittance at wavelength of 800nm. As shown in figure 3-3, Attenuation rate of Ni/SiO2 optical attenuation slice was increased first and then decreased at 0.4Pa and 0.6Pa, it was not the ideal state that too large or too small sputtering power. Maximum light attenuation rate and excellent performance were reached at 600W, but poor surface morphology and flatness, not uniform power through optical attenuation slice at these conditions. Compared with 600W, organizational structure and surface morphology of Ni film were perfect, and little difference of light attenuation rate at 400W.

4 Conclusion

1) film of (111)and(200)crystal orientation was obtained on Ni/SiO_2 substrate.
2) Surface was also smooth, particle distribution was uniform and arrangement of particles were compact at 400W working power.
3) Attenuation rate reached 0.52 at 0.4Pa and 400W, which can meet the requirements of optical fiber communication.

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