

Compared to Performance of Ni / SiO₂ Optical Attenuator by Two Preparing Methods

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Abstract. In this paper, the preparation of Ni / SiO₂ optical attenuator using two kinds of process, were discussed for electroless plating and magnetron sputtering technology, by analyzing Ni film appearance, surface morphology, film composition, SiO₂ substrate and Ni film adhesion, known magnetron sputtering Ni film in all aspects of performance are better than electroless plating Ni film. Electroless plating Ni film quality not up to such requirements, can not be used in the practice. Conclusions: performance of Ni / SiO₂ Optical Attenuator more practical and reliable by magnetron sputtering process preparing.

1. Introduction

Optical attenuator is an photonics logic device getting the extra light in the optical path of the light intensity attenuated to some extent, to reduce and control the optical power[1.2], the core component is an optical attenuator[3], the light attenuation of preparation and research has always been the hot spot of the scholars and manufacturers at home and abroad. Preparation of light attenuation method has many: electroplating, electroless plating, vacuum deposition and magnetron sputtering process, etc. In the industrial mass production, people not only care the overall performance of products but also consider the manufacturing cost, in the above process, both electroplating and electroless plating process are simple, inexpensive, and easy to operate, but there are waste liquid produced, pollution the environment[4]; vacuum deposition is a physical vapor deposition process, the film thickness of micron level[5]; advanced magnetron sputtering technology, nanoscale thin films can be prepared, better quality, is currently a widely used means. Compared to other methods, magnetron sputtering coating with high film forming rate, low substrate temperature, membrane adhesion good advantages such as coating, and on the environment pollution-free, suitable for low carbon requirements, is a green manufacturing technology, is one of the most promising surface coating technology[6.7.8.9.10].

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2. Experiment

Magnetron sputtering: test equipment for magnetron sputtering apparatus HDJ - 800. Based on magnetron sputtering apparatus type and metal Ni performance design, target material for ferromagnetic metal nickel target, the target material should not be too thick, specifications for phi 55 * 3 (mm), Figure 1 is a self-made target physical dimension drawings.

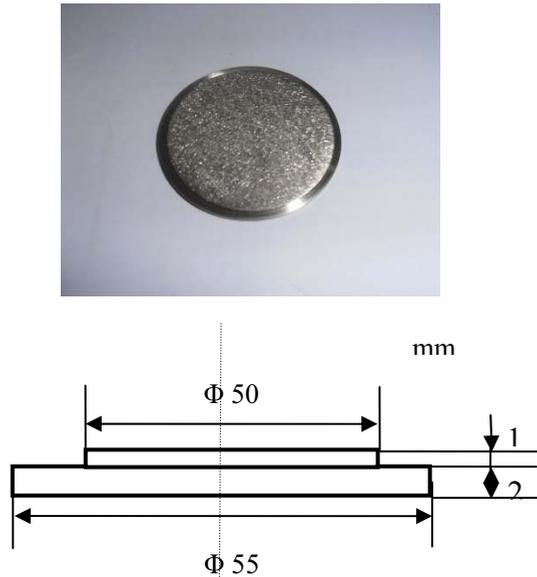


Fig.1 Picture of Ni target dimensioned drawing

Electroless Plating: with ZnSO₄, hydrazine hydrate, ethylenediamine, sodium citrate, EDTA disodium as experimental material, we took control of variables, prepared Ni / SiO₂ optical attenuator specimen. To ensure the quality of the film, inhibiting spontaneous decomposition of the bath, the bath was added stabilizer and complexing agents, and strictly control the bath temperature and pH.

Ni / SiO₂ characterization: Metal film strongly bonded to the substrate film is an important indicator of quality to examine, there are a variety of evaluation methods binding force, wherein the friction polishing test method is one of the most common methods of ultra-thin coating adhesion test, the principle is when the sample is friction and polishing, under the influence of the friction and heat, the sample coating surface polished will harden and heat, this time, in the poor adhesion area, the film will be separated from the substrate blistering. And with a precision impedance analyzer testing the volume and resistivity of tested sample to characterize Ni binding force strength between film and substrate.

3. Results and Discussion

3.1 Compare on Exterior appearance of two samples

Figure 2 (a) is a chemical plating samples, (b) a sample of magnetron sputtering system. Observing the sample (a) visible, Ni film was dark black, smooth surface is low; the sample (b), Ni film was silver white and bright color, smooth surface film no clear projections show magnetron sputtering method optical attenuator coating was dense, smooth, uniform, good continuity, uniform light intensity attenuation, the better .

3.2 Analysis crystal phase of two samples by testing

The plating and magnetron sputtering method samples were analyzed by XRD, black curve in Figure 3 Representative of electroless nickel XRD patterns, red curve represents the magnetron sputtering Ni XRD map, refer to the standard card (JCPDS6-585), the chemical plating membrane preparation and magnetron sputtering nickel diffraction peak with the standard card of pure Ni diffraction peak corresponding to the consistent, at 44° (111), 51° (200), (220) diffraction peak near 76° presence, 44° place diffraction peak of the strongest, 51° , followed, 76° weakest. Described two methods are nickel-plated layer film, and in the (111) direction of the diffraction peak intensity of the maximum peak, it shows that the redox reaction and the sputtering process, Ni film has a (111) preferred orientation; meanwhile, found plating Ni films have miscellaneous peaks, indicating that there is a chemical reaction when impurity phases involved in the reaction, resulting in low layer purity; magnetron sputtering film diffraction peak is higher than the chemical coating, and sharp, indicating that Ni film crystalline state is relatively good, no impurity phase.

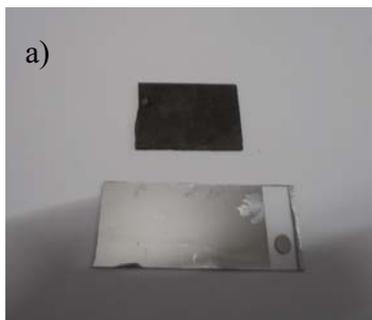


Fig.2 Ni/SiO₂ Samples by different methods

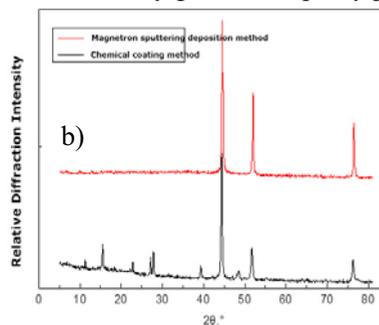
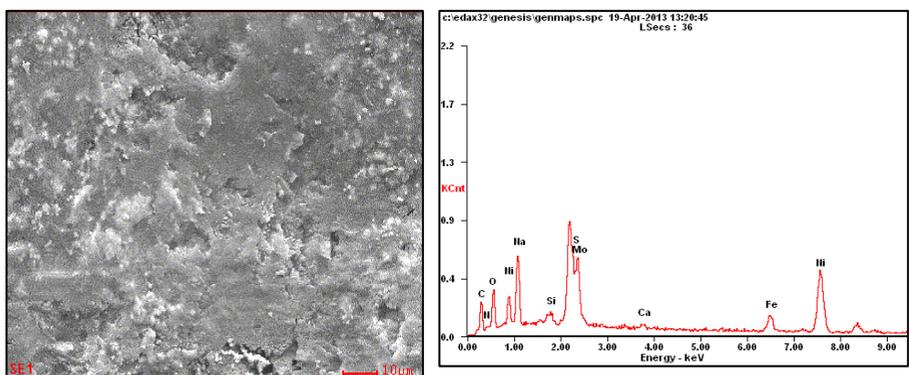


Fig.3 XRD patterns by different methods

3.3 The membrane surface morphology and composition analysis



(a) chemical plating

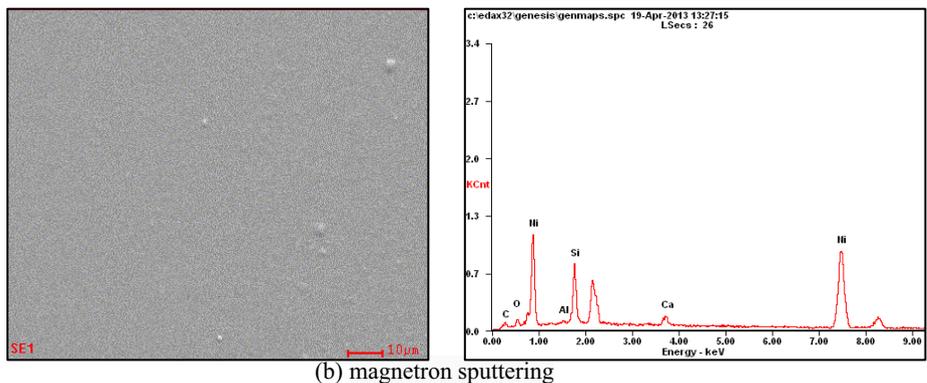


Fig.4 SEM image and EDS pattern of the nickel coating by different methods

Optical signal transmission, it is required light attenuation sheet film surface smooth, uniform thickness, otherwise it will lead to different layers of light attenuation ratio, signal distortion, therefore the surface morphology of Ni film should be studied. Figure 4 is a chemical plating and sputtering metal Ni film SEM image. Figure 4 (a) electroless plating layer surface can be seen that there is a serious large projections and grooves, uneven film thickness, combined with EDS elemental analysis, found that the sample contains more impurities, wherein C, Mo, and S elements high levels, mainly citric acid or ethylene diamine decomposition of carbon deposited on the coating surface, resulting in the coating surface was black. Figure 4 (b) magnetron sputtering Ni film surface smooth, dense, almost invisible small bumps and depressions, combined with EDS spectrum analysis, found that the film mainly composed of Ni, Si and O three elements, including Ni element mass fraction higher, reaching 72.69 percent, through the surface morphology and EDS spectrum analysis comparison, magnetron sputtering coating smoothness and purity Ni films are better than chemical plating, uniform light attenuation, the better.

3.4 Ni film and the substrate binding analysis

The samples were subjected to rubbing, polishing time for 2 min, we could find that electroless Ni membrane has been separated from matrix, magnetron sputtering plating Ni membrane surface have no obvious change, which indicates its combining ability is good electroless Ni film.

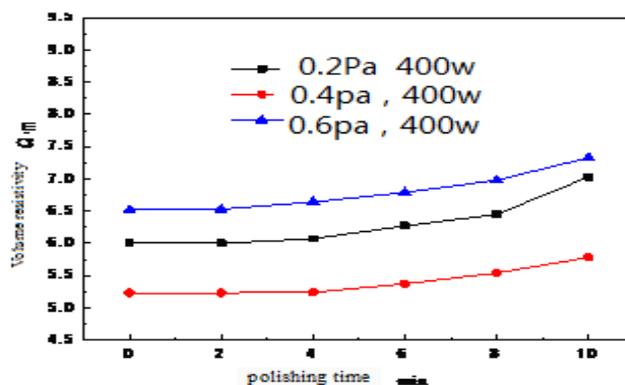


Fig.5 Volume resistivity of samples with different polishing time by sputtering

The use of precision impedance analyzer Magnetron Sputtering Ni film volume resistivity, volume resistivity curves of different optical attenuator polishing time,

Characterization binding force between the film and the Ni sputtering SiO₂ substrate strength[11], Figure 5. As can be seen from Figure 5, a lot of small sample volume resistivity than silica glass, good electrical properties, proved that after polishing, the Ni film did not fall off, and the polishing time increases, the volume resistivity of the less volatile sample, indicating a strong binding force between the magnetron sputtering method to obtain an Ni film and the substrate, and the rub resistance of the Ni film is relatively good.

4. Conclusions

Two different methods are available on the SiO₂ glass substrate plating Ni film. Ni plating film surface roughness, compactness poor, uneven, and the emergence of the phenomenon of skin shedding and Alice; magnetron sputtering Ni film surface have smooth, dense, good substrate and coating adhesion, the degree of crystallinity is better than chemical plating. Electroless plating process is simple, low cost, but the film quality and flatness can not reach the required specifications, it can not be used in the practice; the higher cost of magnetron sputtering equipment, coating speed, high efficiency, the coating layer is excellent in performance, as the light fades sheet long service life, replace the number of small, high cost, to meet the needs of industrial mass production.

5. Acknowledgements

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