

# EXCITATION OF RESONANCE PHENOMENA DURING THE MAGNETRON SPUTTERING OF THIN METALLIC FRACTAL FILMS

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## Abstract

Regular structures on the surface of materials give to them uncommonly properties [1]. In the report are given some results of investigating the resonance phenomena, which appear under the cap of installation for the magnetron sputtering during the arrangement under it of semiconductor plate with the self-affine relief of surface. Some results of investigating the resonance phenomena, which appear under the cap of installation for the magnetron sputtering are given. These phenomena are excited by the device, which is silicon disk with the self-affine relief of surface.

**Keywords:** surface, magnetron sputtering electromagnetic wave, semiconductor, thin metallic film, fractal nano-surface.

## 1 Introduction

Application of nano-dimensional objects with the fractal structure, as a result of their self-similarity, promises wide field for their application in the most different devices. For understanding of their nature and behavior it is necessary to consider the phenomena, which earlier into the examination did not start to search for the new methods of description with a simultaneous study of the properties of such objects. In this case should be isolated not only physical properties as, for example, electrical conductivity, but also geometric properties and their connection with the physical.

This is especially urgent for the thin nano-dimensional metallic films with the fractal structure of the surface [1,3].

## 2. Formulation of the problem

It is known that all metals have the monotonic and unique dependence of resistance on the temperature. It is known also, that the thin films have some special features in the temperature dependence. It was revealed the anomalous behavior of thin films and the effect of "memory", which was expressed in the "memorization" of the highest value of resistance, achieved with the heating by the films with the fractal structure of surface [2].

Thus, it is necessary to conduct a study for the development of the reasons for this behavior of thin nano-dimensional metallic films with their heating.

## 3. Installation and results of investigation

Magnetron sputtering is accomplished on the installation, represented in Fig. 1. Installation consists of the cap, under which are located cathode and the dielectric or semiconductor base layer of sputtering. From the hearth of cap is drawn off air. The anode is located under the base layer. During application between cathode and anode of stress, appears the particle motion of the metal of cathode to the side of the anode. These particles precipitate out to the base layer. This process proceeds at a temperature of approximately 400 °C.

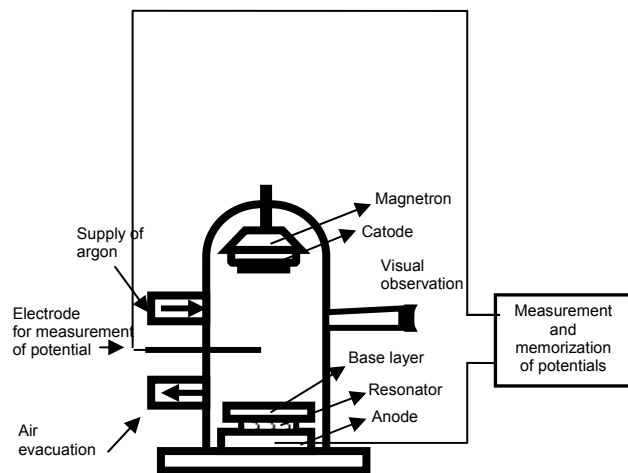


Fig. 1. Installation for magnetron sputtering and measurements devices

Earlier [1] it was shown that the thin films with the uncommon properties are obtained during the application in the process of sputtering the additional device. This device is silicic plate in the form of disk, with the self-affine relief from the circles substituted to its surface (Fig. 2).

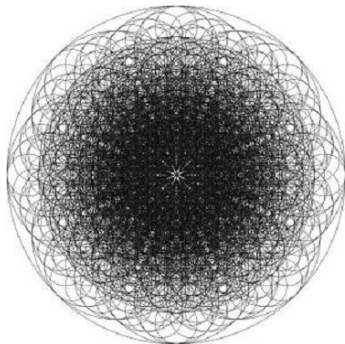


Fig. 2. Relief from the circles on the surface of the resonator

For the designation of this device in the text we will further use term "resonator". Image of resonator is showed on the Fig.3. .

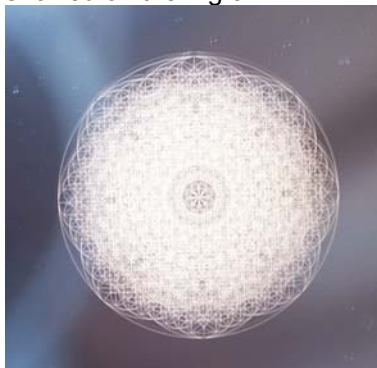


Fig. 3. Resonator

Thus the magnetron sputtering of metallic films to the dielectric or semiconductor surface occurs under the action of the forces, which have electromagnetic and thermal nature and it can be examined as dissipation dynamic system. The electrodes were introduced for the development of the reasons for obtaining films with the indicated properties into the space under the cap. With their aid potential changes between the cathode and the anode in the process of magnetron sputtering were measured (Fig. 4).

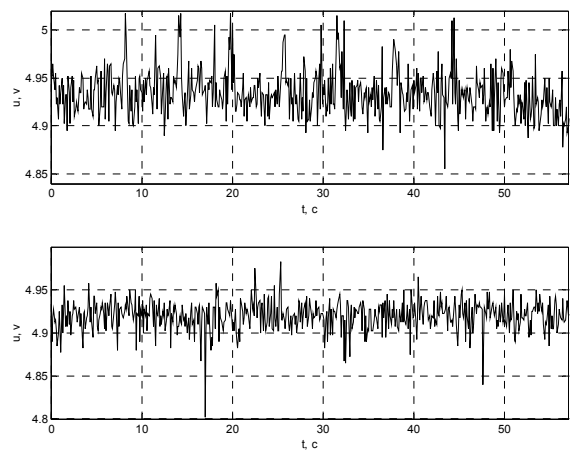


Fig. 4. Changes of the potentials with the time. Upper diagram. present potentials changes without the resonator, lower diagram with the resonator

For establishing the connection between the regime of sputtering and the structure of surface film were executed the measurement of electric potential under the cap of installation [3]. For this into the installation of magnetron sputtering was introduced the probe, with the aid of which was measured the potential at the different heights between the cathode and the anode (Fig. 1). Measurements were made both with the presence of resonators and with their absence. A change of the potentials with time they are given in Fig. 4, and the spectral power densities of electric potentials during the sputtering in the presence of resonators and in their absence are given in Fig. 5. These curves show that the redistribution of energy in the oscillation spectrum occurs. Resonator sharply strengthens fluctuations at the frequency of approximately 3 Hz and suppresses at the frequency of approximately 1 Hz.

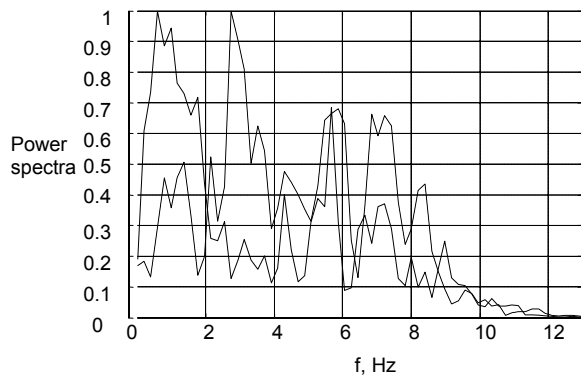


Fig. 5. Spectral power densities for the fluctuations of potentials in Fig. 4.

Solid line: resonator it is absent,  
dot-dash line: sputtering is conducted with the resonator.

The presence of resonator under the cap for the magnetron sputtering leads to the synchronization of fluctuations. This causes the redistribution of energy of fluctuation of electromagnetic field along the spectrum. The mechanism of this phenomenon also was studied in [2] and was examined in the report: Kopyltsov, Lukyanov and Serov "Coherent emission of electromagnetic radiation from the surface of semiconductor plate with the self-affine relief", made at this conference.

The images of surfaces of the films were also obtained by the method of the scanning probe microscopy (Fig. 6) [3].

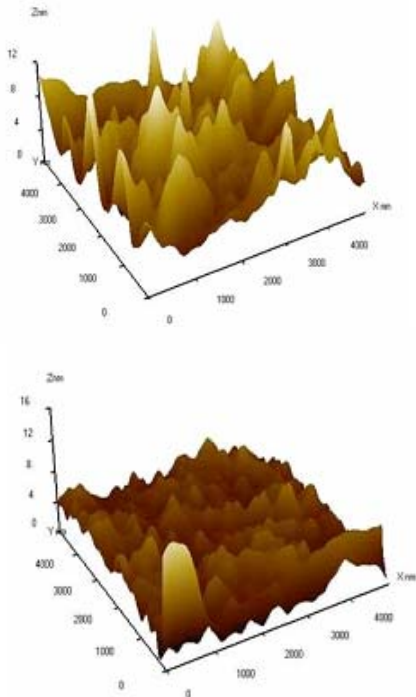


Fig. 6. Results of scanning probe microscopy.  
Above: Film is manufactured without the resonator

Below: Film is manufactured with the resonator  
Sizes along the axes are indicated in the nanometers.

Images on Fig. 6 showed the difference in the nature of the relief of films. The film which is prepared without the resonator has the chaotic relief of surface. The film which is prepared in the presence of resonator, has the more regulated relief with the fractal structure. The properties of this structure were in detail described in [4].

## Conclusions

The redistribution of energy of the fluctuations of electromagnetic field in the process of magnetron spraying leads to the formation of metallic films with the fractal structure of surface. Some of the properties of these films were investigated and described earlier in [1,4].

The resonance, which leads to the redistribution of energy of the fluctuations of electromagnetic field (Fig. 5), is the reason for this.

## References

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