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INVESTIGATION OF SOLID STATE REACTIONS IN Ni/Si SYSTEM

S. S. Shenouda[1,2], D. L. Beke[1]

[1]University of Debrecen, Department of Solid State Physics, H-4010 Debrecen, P.O. Box 2, Hungary.

[2]Ain Shams University, Department of Physics, Faculty of Education, Roxy, Cairo, Egypt.

Abstract

Last year, we finished studying the Ni_2Si/crystalline-Si system (see last report). Hungarian patent has been handled and accepted for that work. In this year, we tried to investigate the solid state reactions in Ni/Si system. The samples were prepared using DC magnetron sputtering. Here are some preliminary results for Ni/crystalline-Si and Ni/amorphous-Si. Heat treatment at 180 ^{o}C leads to formation of reaction layer at the interface. The intensity-sputtering time profiles were determined by means of Secondary Neutral Mass Spectrometry.

I. Introduction

The primary interest in nickel monosilicide (NiSi), an intermediate compound in the Ni–Si binary system, is due to its usefulness as a contact material in microelectronic devices and in aggressively down-scaled complementary metal–oxide-semiconductor (CMOS) devices [1,2]. NiSi films offer low specific resistivity, low contact resistivity, low formation temperature, and low consumption of Si during silicidation [2,3].

In this work, we will study the solid state reactions of the nanocrystalline Ni with both the crystalline Si and the amorphous Si substrares. Also, the shift of the interfaces will be taken into account. Many trials are done to determine precisely the position of the interface.

II. Experimental Techniques

Ni(20nm) and Ni(20nm)/a-Si(50 nm) were deposited onto crystalline Si substrate by DC magnetron sputtering at room temperature. Disk-shaped Ni and Si targets with diameter of 2 inches were used as sputtering sources. The silicon substrate was etched by HF acid. Then, the films were deposited by sputtering in Ar (99.999%) pressure of $5x10^{-1}$ Pa(under dynamic flow. The sputtering power was 40 W. The sputtering rates were calculated from the layer thickness measured by AMBIOS XP-1 profilometer. The samples were annealed in high vacuum furnace ($1x10^{-4}$ Pa) at 180 ^{o}C for different annealing times.

The intensity-sputtering time profiles were measured using a Secondary Neutral Mass Spectrometry (INA-X, SPECS GmbH, Berlin). The SNMS device works with noble gas plasma and the bombarding ion current has an extremely high lateral homogeneity. The low bombarding energies (in order of 10^2 eV) and the homogeneous plasma profile lead to an outstanding depth resolution(<2 nm) [4-6]. In this case, the detection limit of the SNMS is about 10 ppm. Details of quantification procedure of SNMS spectra are described in [4,7,8].

III. Result and discussion

The measured intensity-sputtering time profile of the as deposited Ni/c-Si is shown in Fig. 1(a). With annealing at 180 ^{o}C for different annealing times, solid state reaction between the nanocrystalline Ni and the crystalline Si leads to formation of reaction layer. Fig. 1(b) shows the intensity-sputtering time profile of the annealed sample for 1h as representative example. This layer was formed with the consumption of the parent Ni and Si. It is clear that there is no Si diffusion along the grain boundary of the Ni. For further investigation of the solid state reaction in this system, the effect of Pt on these reactions will be studied

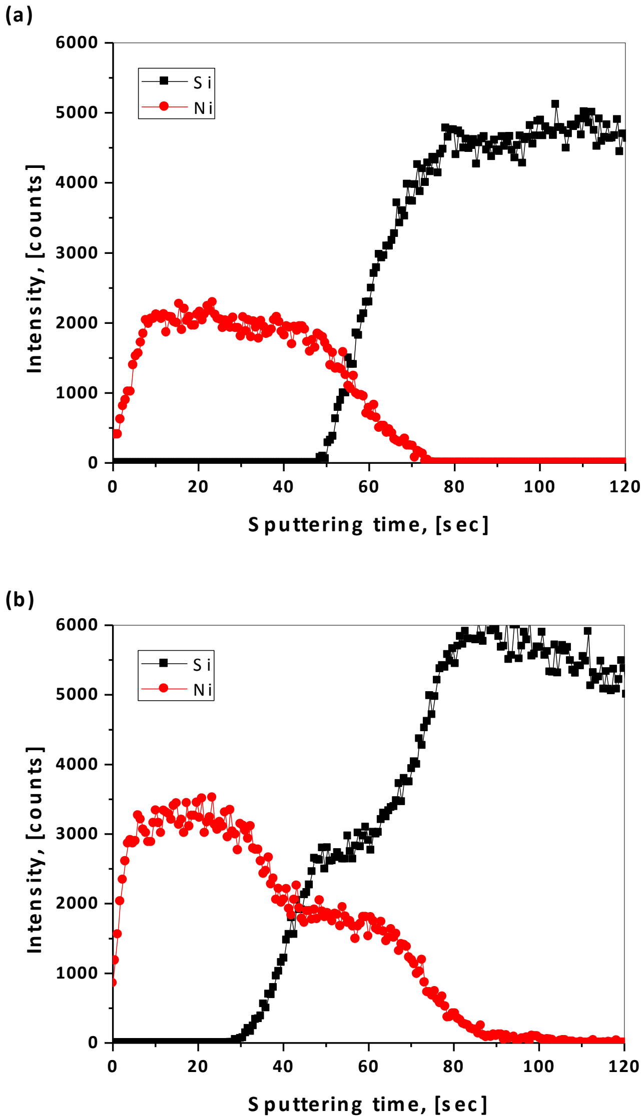
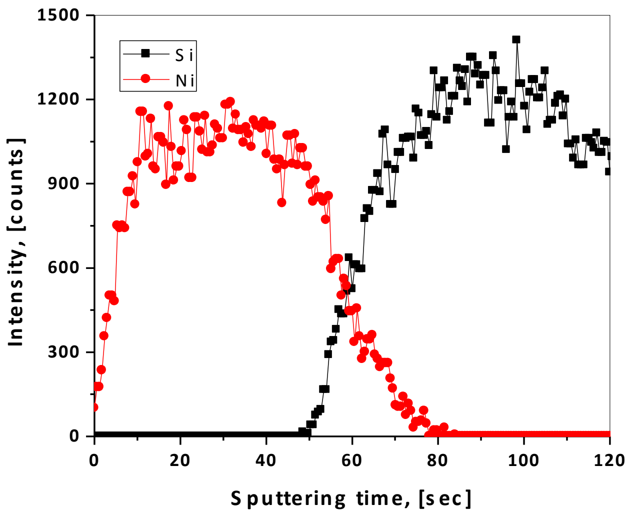


Figure 1: Intensity-sputtering time profile for Ni/c-Si; (a) as deposited, (b) annealed at 180 ^{o}C for 1h.

Regarding the solid state reaction between the nanocrystalline Ni and the amorphous Si, Samples of Ni/a-Si were annealed at 180 ^{o}C for different annealing times. Figs. 2(a) and 2(b) shows the intensity-sputtering time profile of the as deposited and the annealed samples, respectively. It can be seen that a wider reaction layer is formed after annealing. This reaction layer seems to be different from that formed in Fig. 1(b). Thus, type of the Si influence the solid state reaction. Also, there is no Si diffusion along the grain boundary of the Ni.

There are many trials under process for converting these profiles to concentration-depth profiles. These trials depend on calculating the sensitivity factors of the elements and measuring the depth of the crater at different positions along the time axis. These new profiles will help in determining the structure of the reaction layer. Also, it will help in the correct choice of the position of the interface. This aims to investigate the shift of the individual interfaces of this layer precisely.

(a)



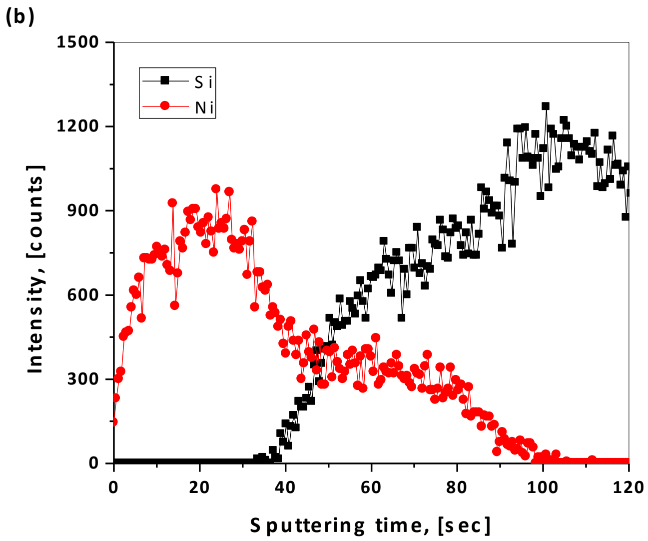


Figure 2: Intensity-sputtering time profile for Ni/A-Si; (a) as deposited, (b) annealed at 180 °C for 1h.

IV. Conclusion

Solid state reaction of the nanocrystalline Ni with both the crystalline and amorphous Si leads to formation of reaction layer. There is no Si diffusion along the grain boundary of the nanocrystalline Ni. There is qualitative difference between the crystalline and amorphous Si. Our future work is to study the kinetics of growth of the product layer and the shifts of the individual interfaces. Furthermore, the characterization of the studied systems by XRD will also be carried out.

Acknowledgement

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