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DIFFUSION OF ARSENIC IN ION IMPLANTED STEEL

Abstract

Samples of stainless steel 1H18N9T were implanted with arsenic /radioactive isotopes 76 As/ at energy 40 keV. After implantation the samples were annealed at 400°C - 700°C in vacuum and oxidizing atmosphere. The concentration profiles of arsenic were measured using the residual activity method combined with the ion etching removal technique. The temperature dependence of the diffusion coefficients of arsenic ion implanted in steel /1H18N9T/ and activation energy of diffusion have been determined.

Introduction

The ion implantation is one of the basic steps in semiconductor manufacturing. However, the interest in the ion implantation technique for non-semiconductor application can be noted recently [1-4]. The modification by implantation of metallic surface properties such as corrosion, friction, hardness, and wear behaviour have already been discussed by numerous authors [5-9]. The reason is that by implantation the properties[6] of materials can be significantly changed in the region near the surface. Therefore, the redistribution of impurities in ion implanted metals is relevant to the application of ion implantation to these fields and also the information of the depth distribution profiles of implanted atoms has been important for the st-udy of basic mechanisms.

This work was undertaken with two major aims: firstly, to determine the temperature dependence of the diffusion coeffi-

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cient D for arsenic in stainless steel; secondly, we wish to study the redistribution of an initial impurity profile during the thermal oxidation annealing because of the usage of the implanted tools or other arrangements at different temperatures during their activities.

Measurements and Results

We used mechanically polished samples of stainless steel 1H18N9T /Cr - 18%, Ni-9%, Ti-0,9%, Mn-2%, C 12%/. The samples were implanted with ^{76}As ions to the dose about 10^{10} ions/cm^2. The implantation has been performed at energies of 40 keV and 45 keV at room temperature, The annealing was carried out either in vacuum or in oxidizing atmosphere for 30 min in the temperature which ranged from 400°C to 700°C. The concentration profiles of arsenic were determined by means of the residual activity method combined with the ion etching technique.

The arsenic depth distribution profiles in ion implanted and annealde in vacuum stainless steel samples are illustrated in Fig.1. The diffusion coefficients were derived using the same method as described in 10 and the Arrhenius plot is presented in Fig 2. The activation energy E = 0.56 eV has been obtained.

The diffusion profiles after annealing of the implanted samples in oxidizing atmosphere as a function of temperature are illustrated in Fig.3. These measurements show a significant difference in arsenic concentration profiles in comparison with the profiles obtained after annealing in vacuum. The strong shift of the profiles into the deeper layers has been observed. This effect is connected with the ejection of arsenic during the oxidation of the surface layers.

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Conclusion

In this paper it has been shown that the arsenic profiles in the implanted stainless steel may be shifted during annealing in the oxidizing atmosphere. The displacement of the concentration profile is strongly dependent on the annealing temperature.

It is speculated that the effect of the impurity-concentration-profile movement toward the deeper part of the sample is due to the impurity diffusion stimulated by the oxidation process of the surface layer during the heat treatment at higher temperatures.

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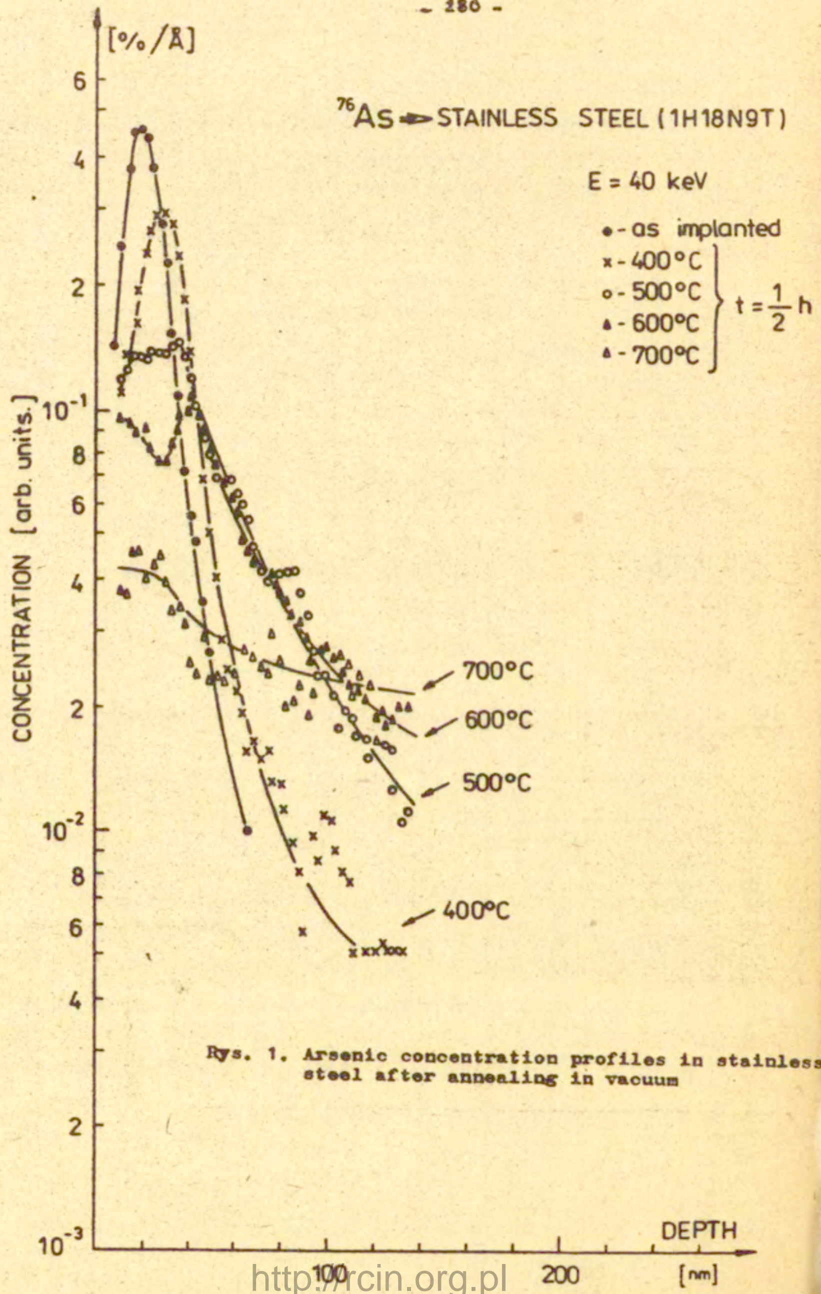

Rys. 1. Arsenic concentration profiles in stainless steel after annealing in vacuum

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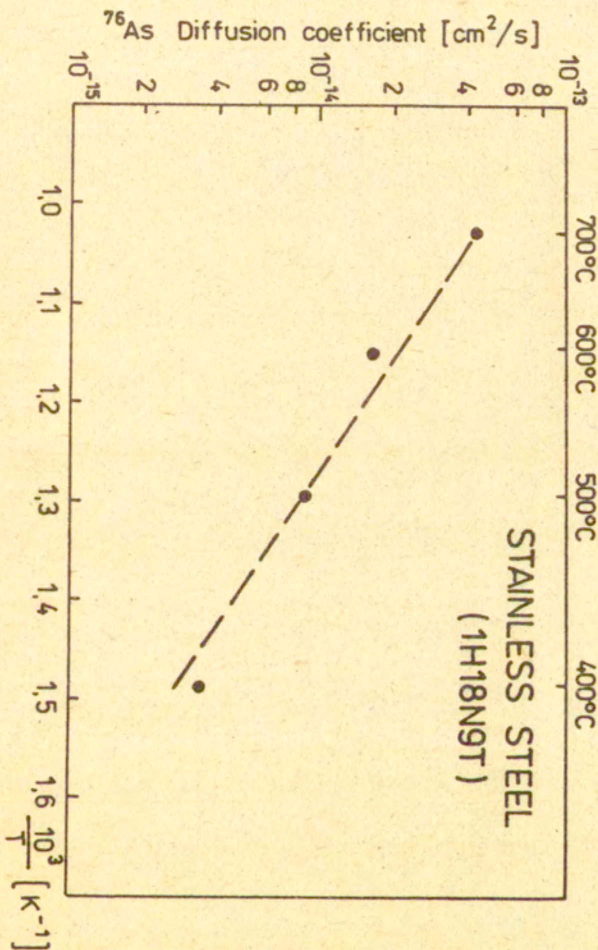

Fig. 2. Arrhenius plot for arsenic diffusion in stainless steel

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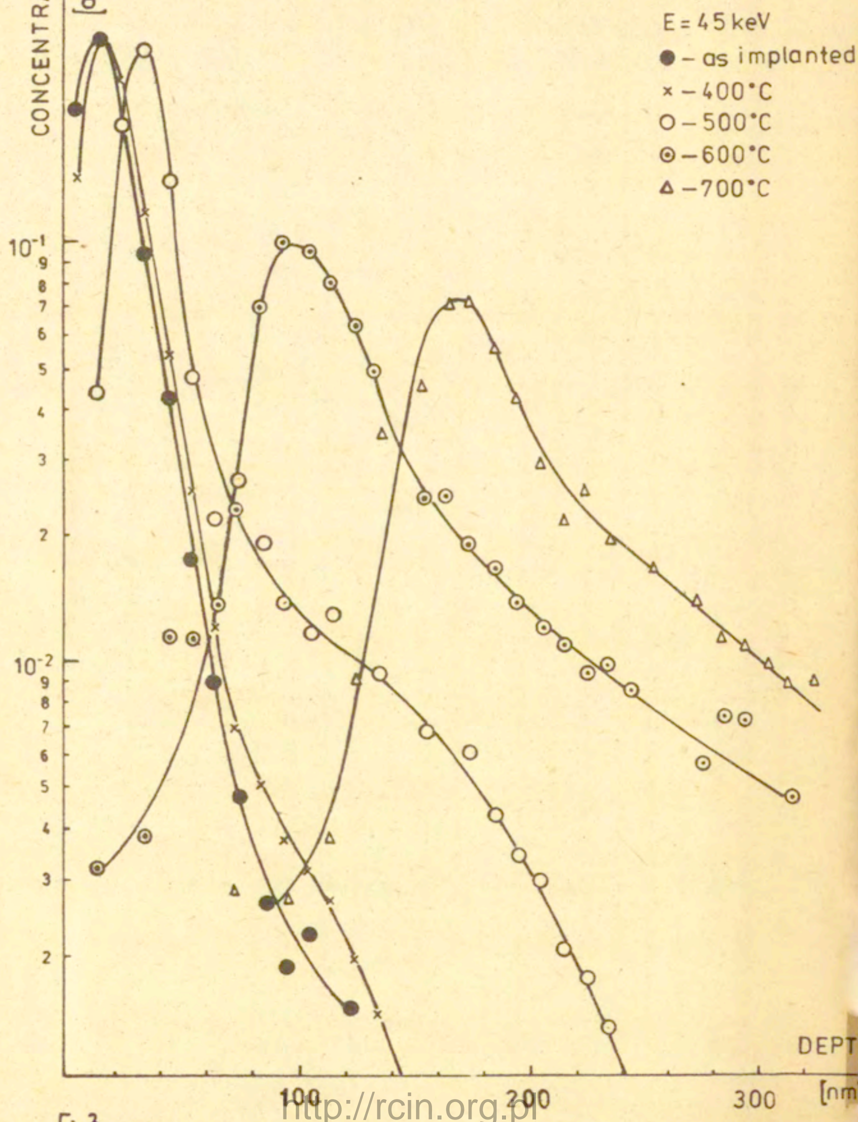

Rys. 3. Arsenic concentration profiles before and after annealing in oxidizing atmosphere

Fig.3

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