Control of magnetic metal plating process on Si wafer by changing dopant density

N. Shimamoto[1], T. Kagasaki[1], J. Kawaji[1], T. Homma[1], T. Osaka[1,2] and I. Ohdomari[1,2]

[1]Graduate school of Science and Engineering, Waseda University
3-4-1 Ohkubo, Shinjuku-ku, Tokyo, Japan
169-8555

[2]Kagami Memorial Laboratory for Materials Science and Technology, Waseda University
2-8-26 Nishi-waseda, Shinjuku-ku, Tokyo, Japan
169-0051

Introduction

In the field of high density recording media, deposition and patterning methods of magnetic materials have been studied to realize the patterned media devices. In order to fabricate these devices by electrolytic and electroless deposition techniques, the control of electronic properties of substrates is significant.

Silicon is the most important semiconductor for the electronics industry. It is well known that Si properties, *e.g.* resistivity, Fermi level, are tuned by doping, introduced by diffusion techniques, ion implantation techniques and so on. It seems that these doping techniques of semiconductor electrods can be applied to the redox control of electrochemical process.

The aim of this work is to realize fine electrodeposition processes of magnetic metal on semiconductor electrode. It is considered that doping techniques are effective methods to control electrodeposition process by Si electrode. Thus we investingate the effect of dopant density of Si electrode on the Ni deposition behavior.

Experimental

In order to study Ni electro-deposition properties on Si, Cyclic Voltammetry (C-V) mesurement was performed using Ni bath ($NiSO_4 \cdot 6H_2O$, CH_3COONH_4, $NaH_2PO_2 \cdot H_2O$) with Ag/AgCl reference electrode, Pt counter electrode and Si working electrode. The Si electrodes were made from n-type or p-type Si wafer (100) with various dopant densities, which were estimated from the four-point probe resistivity measurements of Si wafer.

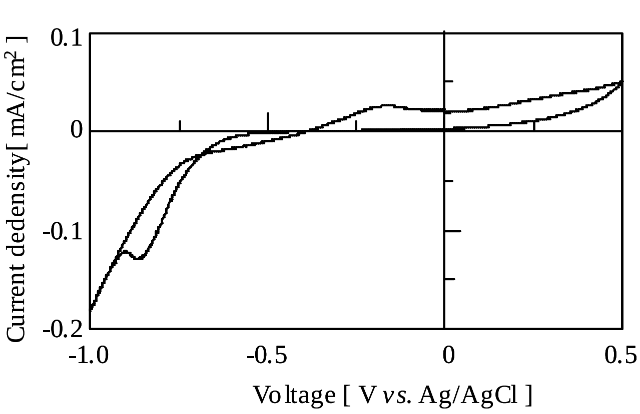

Figure 1. Cyclic Voltammogram curried out at Ni plating bath and Si electrode. The dopant density in Si is 9.9 x 10^{13} cm^{-3}, P.

Results and Discussion

A result of C-V measurement by n-type Si electrode is shown in Fig. 1. Typical C-V curve of Ni electrochemical reaction is observed. Two peeks, –0.128 mA at –0.871 V and 0.026 mA at –0.164 V, correspond to Ni reduction and oxidation reaction, respectively. In order to clarify the control parameters of the Ni deposition process, we study the relation between the reduction peek value and dopant density in Si electrodes. As shown in Fig. 2, the reduction peek voltage changes from –0.871 V to –0.734 V gradually as dopant density increases. The reduction current density change as shown in Fig. 3. The maximum current is –1.2 mA/cm^2 at 8.9 x 10^{15} cm^{-3}. Qualitatively, this phenomenon can be explained the interaction of two factors as follows; one is the increment of Si conductivity as the dopant density increases. Another is the decrement of reduction reaction as the potential drops depending on dopant density (Fig. 2).

These results indicate that Ni electrodeposition process can be controllable by using the Si electrode with doping techniques.

Acknowledgement

This work was done by Grant-in-Aid for the Center of Excellence (COE) Research program “Molecular Nano-Engineering and Its Development into Microsystems” and the 21COE program “Center for the Practical Nano-Chemistry” from Ministry of Education, Culture, Sports, Science and Technology, Japan and partially supported by the Mutual Aid Corporation for Private Schools of Japan.

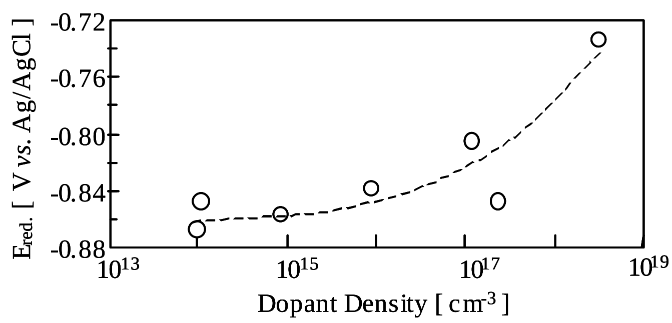

Figure 2. Dependence of reduction voltage on dopant density in n-type Si electrode.

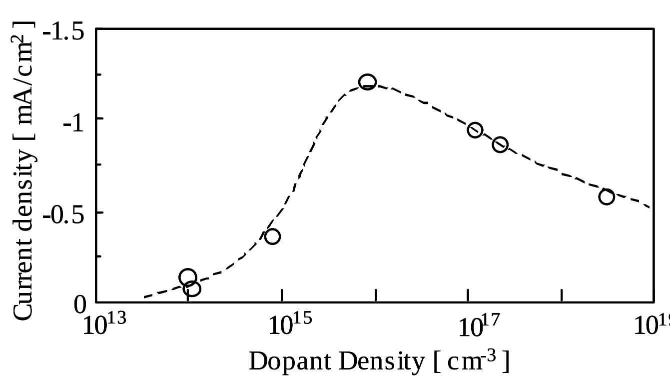

Figure 3. Plots of Reduction peek current density *vs.* dopant density of n-type Si.