Vol.1 No. 1-2 NUCLEAR SCIENCE AND TECHNIQUES May 1990

BORON PROFILING IN SILICON BY $^{11}B(p,\alpha)^8Be$ REACTION AT E_p=2.4 MeV

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(Received November 1989)

ABSTRACT

The reaction $^{11}B(p,\alpha)^8Be$ was used to profile boron concentration in silicide. The energy of incident proton of 2.4 MeV was selected. The samples were Ti silicide implanted with 80 keV and 230 keV BF_2. The experimental results indicate that the behaviour of boron is different from that of fluorine during silicide formation.

Key words: Boron profiling Ion implantation

I. INTRODUCTION

Boron is one of the main doping elements in the semiconductor. In order to eliminate boron channeling tail in the ion-implantation, one of the improvements is to use $^+BF_2$ implantation[1-2], in which B atoms only share ~1/5 molecular energy. A shallow p-n junction could be obtained, moreover, shallow junctions and silicide could be produced simultaneously[3-4]. During processing the tribution directly influence junction characters and contact resistance. SIMS and Auger are commonly applied to profile boron. But both methods are not quantitative and absolute. $^{11}B(p,\alpha)$ ^8Be reaction has been used to analyse boron[5]. There are several energy region chosen for analysis. The first one is near 167 keV, with small cross section. The second one is near 0.65 MeV with very high cross section. Due to Be dissolution and a 12 μm Mylar film was mounted in front of the detector, α_0 energy spectrum will be dispersed very heavyly. Therefore these two energy regions could not be used to profile boron concentration. The third one is near 2.4 MeV with cross section about $4\times10^{-31}m^2$, and the α_0 energy is about 5.89 MeV at 170°. We have used reaction $^{11}B(p,\alpha_0)^8Be$ at 2.4 MeV to measure boron profile by spectrum analysis. The result is reported in this paper.

II. EXPERIMENT

Two kinds of samples are used in this work. One is consisted of 80 nm $TiSi_2$ on Si substrate and implanted with BF_2^+ at 80 keV. The dose range is $2-6\times10^{15}$ at/cm². These samples are prepared in Royal Melbourne Institute of Technologh, Australia. The thicknesses of Ti and Si(α) are 120 nm and 20 nm, respectively. Then the samples are implanted with 230 keV, 1×10^{16} $^{+}BF_2/cm^2$ and annealed at 500– 700°C for 30 min. The detail of sample preparation is described in Ref.[3]. The experiment is performed on a 4 MV Pelletron in SINR. α −particles (5.89MeV) are detected by a surface barrier detector at 170° with respect to incident beam. A glancing geometry is chosen to improve depth resolution (~60 nm).

III. RESULTS AND DISCUSSIONS

Fig.1 is a typical α energy spectrum of $^{11}B(p,\alpha)^{8}Be$ reaction. From the spectrum we find that the maximum energy of pileup only reaches ~5 MeV. The yield at the energy region near 6 MeV which we are interested in is much higher than background. Therefore a very clear α spectrum can be obtained.

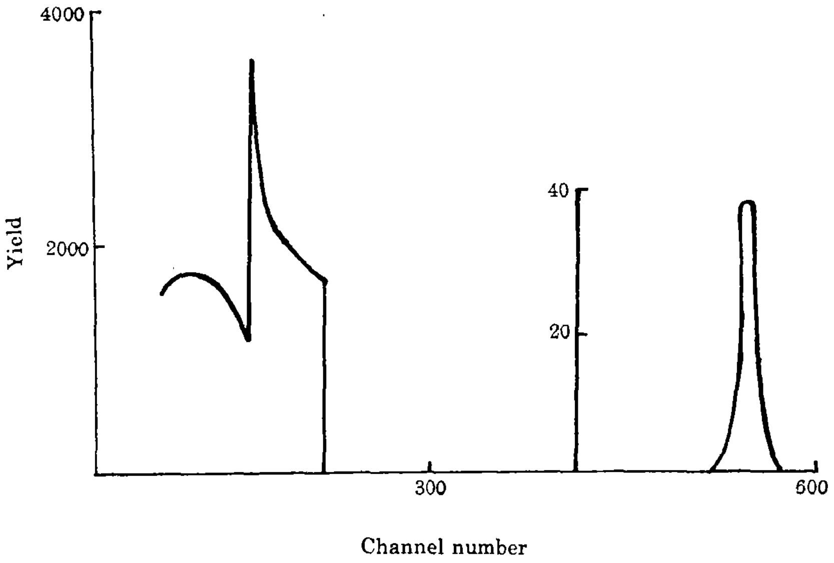

Fig.1 The energy spectrum of $^{11}B(p,\alpha)^{8}Be$ reaction at 2.4 MeV for the sample ($Si/TiSi_2$) implanted with 80 keV, 6×10^{15} BF_2/cm^2

The spectrum from self−supporting pure boron is used to calibrate ^{11}B concentration. We assume that the isotope abundance of implanted ^{11}B is ~100% because that BF_2^{+} mass number is selected at 49 during implantation.

Fig.2 indicate boron distribution in the $Si/TiSi_2$ sample implanted with 80 keV $^{+}BF_2$. *a*,*b* and c represent that at doses of 6×10^{15}, 4×10^{16} and 2×10^{15} BF_2/cm^2, respectively. The two arrows indicate the concentration at surface and interface, respectively. From the spectra detective sensitivity is about 1×10^{20}at./cm^3.

Fig.3 represents boron distribution in the multilayer sample implanted with 230 keV $1\times 10^{16}BF_2/cm^2$ and annealed at 650°C for 30 min. From Fig.3 in Ref.[3], F redistribution is measured and is caused by TiSi$_2$ phase formation. But only one peak of boron appears in Fig.3. The result demonstrates that the behaviour of boron atom is different from that of fluorine atom which are segregated at interface region during TiSi$_2$ formation[3].

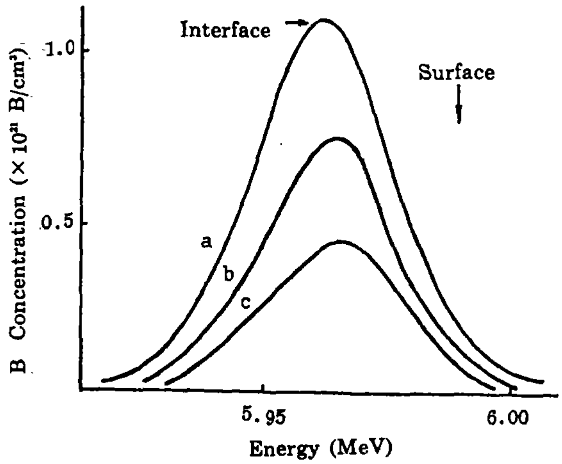

Fig.2 B concentration profiles for (Si/TiSi$_2$)$^+$/cm^2 implanted with 80keV BF$_2^+$

(a) 6×10^{15}BF$_2^+$/cm^2,
(b) 4×10^{15}BF$_2^+$/cm^2,
(c) 2×10^{15}BF$_2^+$/cm^2

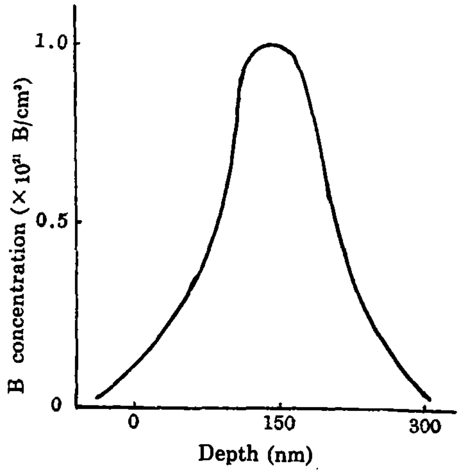

Fig.3 B concentration profile for Si(c)/Ti/Si(α) implanted with 230 keV 1×10^{16}BF$_2^+$/cm^2 and annealed at 650^{0}C for 30 min

ACKNOWLEDGEMENT

A part of samples is prepared in RMIT. The authors would like to acknowledge the cooperation of Prof. J.S.Williams and Dr. Cao Dexin.

REFERENCES

[1] S.R.Wilson et al., *Nucl. Instr. Meth.*, **B21** (1987), 433.
[2] S.B.Felch and R.A.Powell, *Nucl. Instr. Meth.*, **B21** (1987), 486.
[3] Zhu Dezhang et al., *Nucl. Instr. Meth.*, **B39** (1989), 288.
[4] T.P.Chow Katz and G.Smith, *Appl. Phys. Lett.*, **46** (1985), 41.
[5] J.W.Mayer and E.Rimini, Ion beam handbook for material analysis, Academic Press, New York, 1977.