Depth Profiling of Arsenic Shallow Implants in Silicon Using Low Energy Cs Ion Beam on Quadrupole SIMS

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Reported here are results for shallow arsenic of 5 keV and 10 keV implant energies in silicon. 2keV and 5keV Cs^+ primary ions were used at 60° impact angle relative to the normal. The profile shapes were compared. The dose was calculated by comparison with arsenic of 30 keV implant energy.

1.Introduction

Secondary ion mass spectrometry has contributed a lot to the semiconductor industry in the field of elemental depth distribution. These days, in order to acquire accurate profiles in shallow region, "Shallow Depth Profiling" has become a trend in SIMS study [1][2][3] and is also necessary for the semiconductor industry.

It is well known that the use of low impact energy and high impact angle relative to the normal primary ion beam gives better depth resolution and reduces the thickness of surface transient region.

Recently, new high performance SIMS instruments are commercially available for the purpose of shallow depth profiling [3][4].

In this study a rather conventional quadrupole SIMS instrument was used for depth profiling of arsenic shallow implants in Si.

2.Experimental

Depth profiles were acquired with a CAMECA/RIBER MIQ-256 quadrupole SIMS instrument.

A 5kV 5×10^{14} atom/cm^2 ^{75}As implant into Si (sample A), a 10kV 1×10^{14} atom/cm^2 ^{75}As implant into Si (sample B) and a 30kV 1×10^{14} atom/cm^2 ^{75}As implant into Si (sample C) were prepared and analyzed using Cs^+ primary ion at 2keV and 5keV impact energy and 60° impact angle relative to the normal.

$^{75}As^{28}Si^-$ and $^{30}Si^-$ secondary ions were detected.

Sample C was used as a standard for quantification.

The crater depth measurement was performed with the interferometric microscope system Zygo Maxim·3D5700.

3.Results and Discussion

3-1.Shape of profiles

Figure 1 shows a depth profile of sample A, B and C at 5keV impact energy and 60° impact angle.

Figure 2 shows a depth profile of sample A, B and C at 2keV impact energy and 60° impact angle.

In both figures 1 and 2, there are sharp spikes of mass 30 at the very surface. Fragments of surface organic molecules could affect it. But their interference can not be resolved with poor mass resolution of quadrupole instruments. There is also possibility of Si signal enhancement by surface oxidized layer.

Figure 3 shows a depth profile of sample A at 2keV and 5keV impact energy and 60° impact angle. The trailing side of arsenic profile obviously differs.

Figure 4 shows a depth profile of sample B at 2keV and 5keV impact energy and 60° impact angle.

Figure 5 shows a depth profile of sample C at 2keV and 5keV impact energy and 60° impact angle.

Even in figure 4 and 5, a slight difference of profiles acquired with different impact energy can be recognized.

3-2.Dose calculation

Sample A and B were quantified by two procedures. The first procedure was as follows: Normalize the Arsenic profile by the Si intensity, and use RSF acquired from

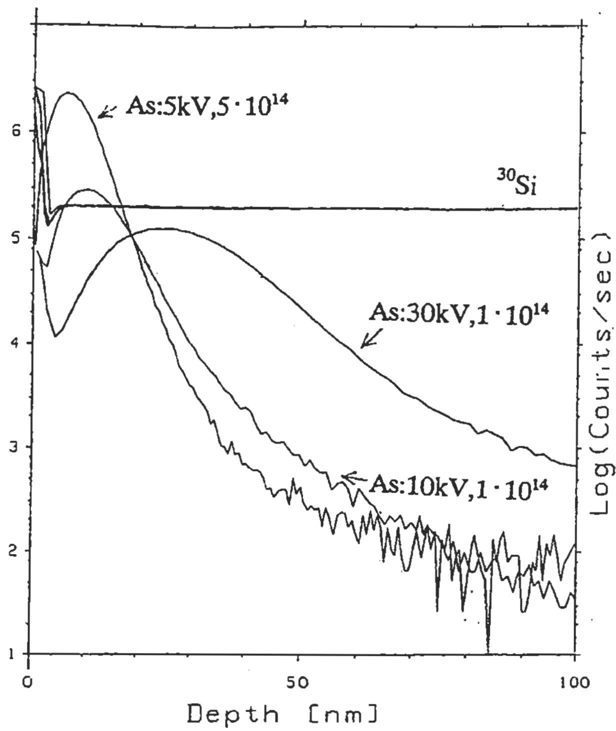

Figure 1. The depth profiles of sample A, B and C at 5keV impact energy and 60° impact angle.

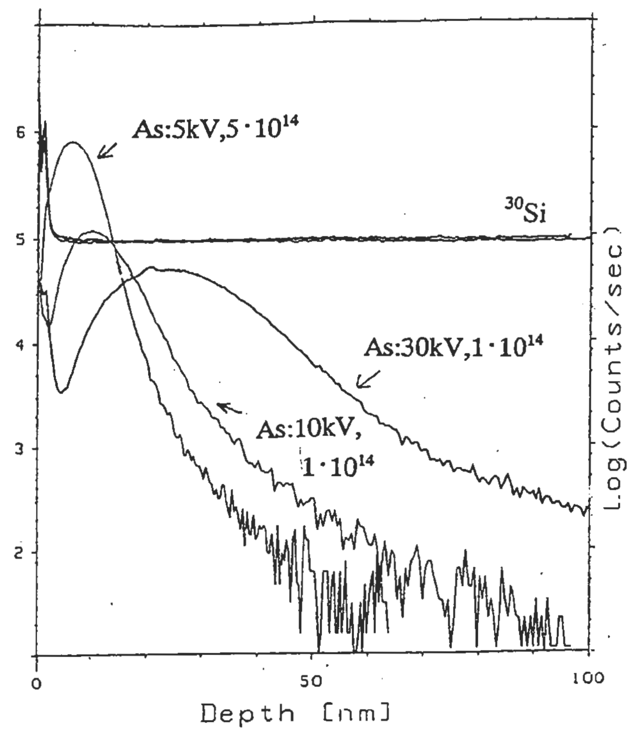

Figure 2. The depth profiles of sample A, B and C at 2keV impact energy and 60° impact angle.

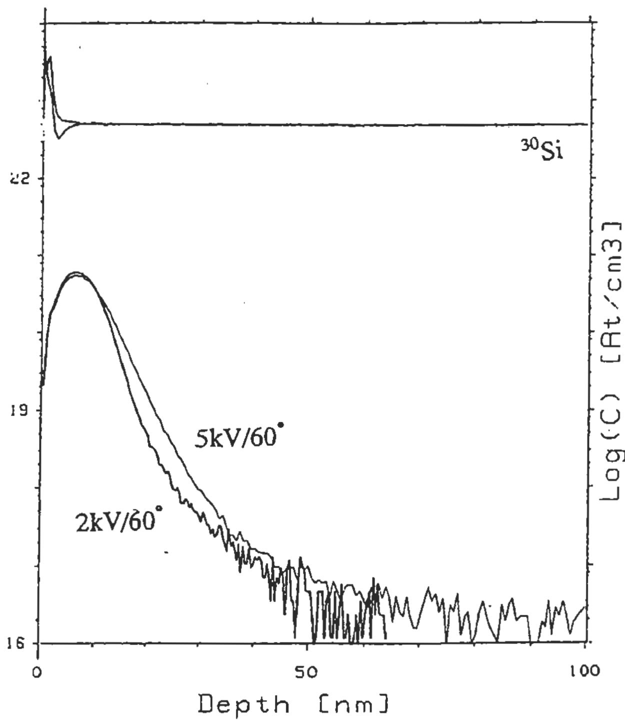

Figure 3.The depth profiles of sample A at 2keV and 5keV impact energy and 60° impact angle.

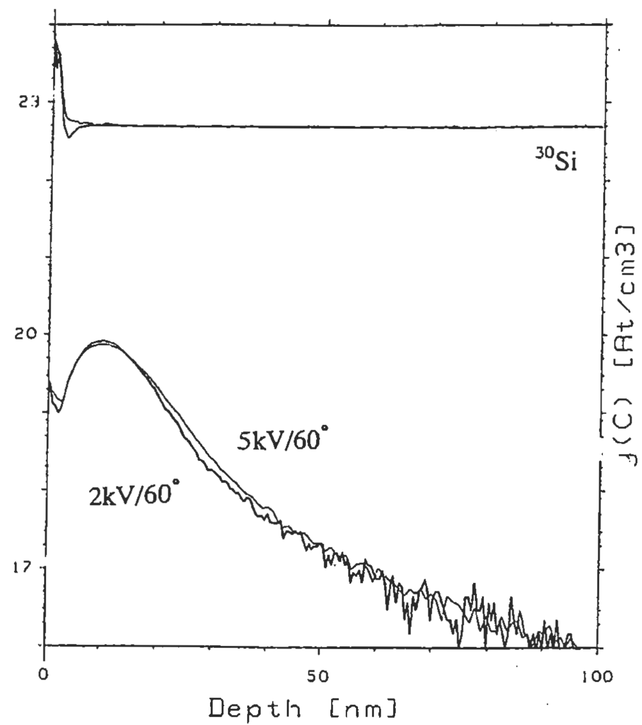

Figure 4.The depth profiles of sample B at 2keV and 5keV impact energy and 60° impact angle.

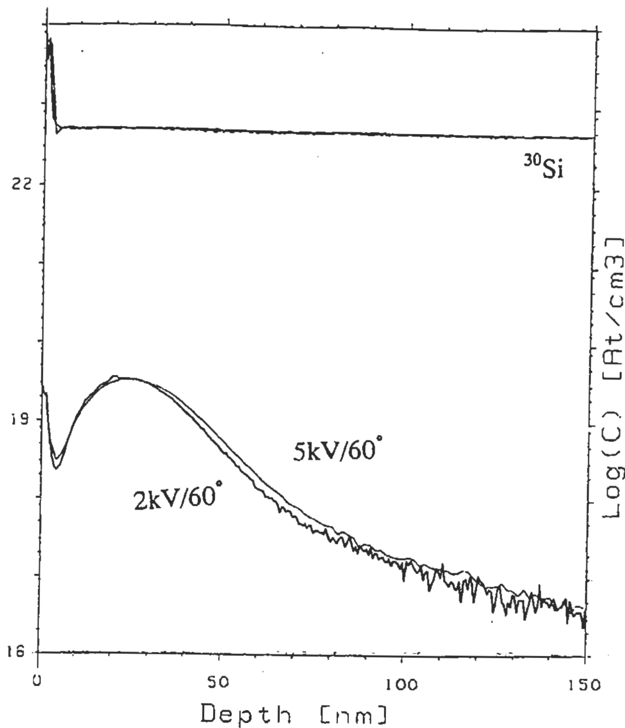

Figure 5.The depth profiles of sample C at 2keV and 5keV impact energy and 60° impact angle.

sample C. The second procedure was as follows: Use RSF calculated with Si intensity at stable matrix intensity region. The calculated doses were shown in table 1.

In case of sample B, the calculated dose was within a 10% margin of error in both procedures and Cs impact energy.

But in sample A, as the high concentration portion of arsenic profile included in the transient region is rather larger, the error was bigger than sample B. Comparing the two procedures, the first procedure gives a larger error. It may be caused by the distortion of the profile in the transient region by normalizing.

In the second procedure , 5keV/60° impact gave a larger value and 2keV/60° impact gave a smaller value.

4.Conclusion

It was shown that the depth profile of arsenic acquired with lower impact energy tends to give a better (similar to the true as distribution) shape.

In case of dose calculation, the second procedure gave better values. The error of the calculated dose did not differ so much between 2keV/60° and 5keV/60° Cs impact.

In case of sample B, the dose was calculated within a 10% margin of error. But in sample A. which is implanted shallower, it was difficult to calculate a dose within a 10% margin of error.

5.Reference

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Table 1: Comparison of implant dose determinations.

	Cs impact	The calculated dose of Sample A (5kV 5×10^{14} atoms/cm^2)	The calculated dose of Sample B (10kV 1×10^{14} atoms/cm^2)
First Procedure	5keV/60°	6.01×10^{14}	1.09×10^{14}
	2keV/60°	6.56×10^{14}	9.74×10^{13}
Second Procedure	5keV/60°	5.64×10^{14}	1.06×10^{14}
	2keV/60°	4.39×10^{14}	9.79×10^{13}