Development of Nissin new boron cluster ion implanter

Nariaki Hamamoto[1], Sei Umisedo[1], Yuji Koga[1], Takao Matsumoto[1], Tsutomu Nagayama[1], Masayasu Tanjyo [1], Nobuo Nagai[1], Tom Horsky[2], Dale Jacobson[2] and Hilton Glavish[2]

[1]Nissin Ion Equipment Co. Ltd.
575 Kuze Tonoshiro-Cho, Minami-Ku, Kyoto, 601-8205, Japan
Phone: +81-75-934-8235 E-mail: Hamamoto_Nariaki@nissin.co.jp
[2] SemEquip Inc.

1. Introduction

Recently, the borohydride cluster ion implantation like $B_{18}H_x^+$ or $B_{10}H_x^+$ is regarded as the one of important technology to form a Ultra Shallow Junction (USJ) beyond 45nm node semiconductor devices [1,2]. To commercialize this technology, we are developing the boron cluster ion implanter with the fast magnetic beam scanning capability, which can control the implantation quality precisely. This system is designed to implant equivalent boron energy from 0.2 to 3keV when using the $B_{18}H_x^+$ and up to 7keV when using $B_{10}H_x^+$, which can cover USJ processes with high through-put. We are to show the present results of this development.

2. Equipment System

The schematic of the system is shown in Fig.1. The ion source is SemEquip's 350 ClusterIon ™ source, which has a large source aperture to extract high current borohydride ion beam, typically more than 30mA @ 1keV equivalent in case of $B_{18}H_x^+$ extraction[3]. Borohydride vapor delivery system and in-situ deposition cleaning system is located just besides the ion source[4].

Beam line is jointly developed by Nissin and SemEquip[5]. Source Analyzing Magnet (SAM) has a large pole gap (116mm) to accept the beam from the large source aperture with a bending angle 120 degree. As SAM is electrically floated, either drift or acc-decel mode can be applied. When the borohydride material is ionized, a number of ions with different mass numbers are produced due to the presence of boron isotopes (^{10}B and ^{11}B) and attached hydrogen. These ions are selected with variable mass resolving slit so that the useful ions (i.e. 210 ±7 AMU in case of $B_{18}H_x^+$ extraction) can pass through to maximize the beam current. The magnetic quadrupole triplet lens (QUAD) plays a role of not only focusing beam in horizontally and vertically, but also correcting these beam centroids of the different mass so that they reach at the same wafer position.

The well focused beam is swept and parallelized with Beam Scanning Magnet (BSM) and Collimator magnet. Implantation is carried out with the realiable endstation of Nissin EXCEED platform. Also implantation is controlled with the same concept of the EXCEED series.

3. System Performance

The alpha-system has been assembled and developments are being carried out. In this section, we are to show the results of $B_{18}H_x^+$ drift mode implantation. Fig.2 shows the wafer through-put measured on this system with 0.5keV 4.5mA equivalent ($B_{18}H_x^+$ 250μA) at the dose 1E15/cm^2. Process time is 102s per wafer which corresponds to the cycle throughput 35 wafers per hour, that is quite high through-put when compared to the monomer boron implantation in drift mode.

It is important that the beam angle deviation should be small, typically within 0.5 degree considering the reliable formation of SDE. The parallelism and beam divergence in horizontal VS. beam current at 0.5keV equivalent is shown in Fig. 3 and 4 respectively. It is understood that both parallelism and divergence is within 0.5 degree even if beam current is changed which prove that the angle is well controlled by tuning the source and beam line parameters.

The uniformity of 0.5keV 1E15/cm^2 equivalent implantation with Therma Wave (TW) measurement is shown in Fig.5, which shows a good uniformity less than 0.3%. Also as-implanted SIMS profile for 0.2keV 1E15/cm^2 is shown in Fig.6. Junction depth defined at the concentration 1E18/cm^3 is around 8nm.

Typical metal contamination data is shown in Table I, which is considered to be acceptable for next generation clean environment requirements for the semiconductor equipment. Also particle increase during implantation is confirmed to be less than 30 (>0.12 μm).

As is well known, when borohydride ion is implanted the self-amorphous layer is formed, which can suppress the channeling and enable good activation after annealing [6]. However, from the equipment point of view, it is better the characteristics should be constant even if the beam density may change. The relationship between sheet resistance and TW value VS. beam current is shown in Table II. In case of lower beam current, there is a little difference in these values, but if the equivalent beam current exceeds namely 2mA, there seem to be no significant change, which should be suitable in process management point of view.

3. Conclusions

New boron cluster ion implanter is being developed with using alpha-type equipment. High through-put at ultra low energy region in drift mode with good implantation qualities is confirmed and presented. We continue to develop this cluster ion implantation technology for mass production.

Acknowledgements

The author would like to thank for all of Nissin's and SemEquip's engineers who contribute to this project.

References

[1] T. Aoyama *et.al,* IWJT(2005) p28
[2] M. Ishibashi *et.al,* IWJT(2005) p31
[3] T. N. Horsky *et.al,* IIT(2006) p198
[4] D. Adams *et.al,* IIT(2006) p178
[5] H. F. Glavish *et.al,* IIT(2006) p167
[6] N. Hamamoto *et.al,* IIT(2004) p95

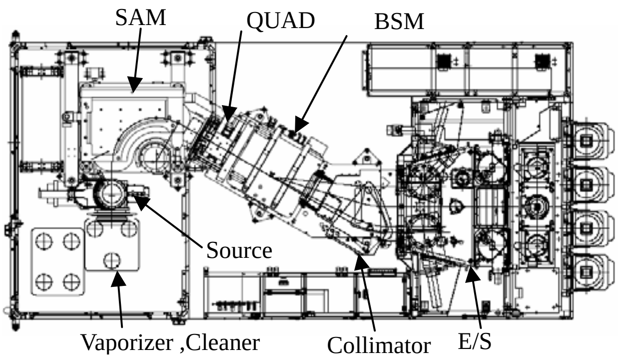


Fig. 1 Schematic of the system

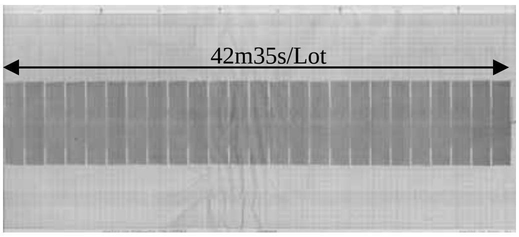


Fig.2 Through-put measurement (B18 - 0.5keV,4.5mA equivalent at 1E15 /cm^2 implantation)

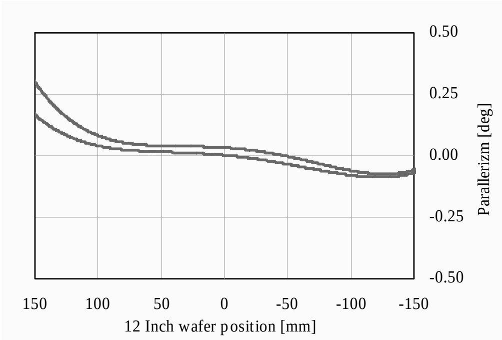


Fig.3 Beam horizontal parallelism (B18 - 0.5keV equivalent)

Atom	Al	Cr	Cu	Mg	Mo	Ni	Fe	W
Result	16	-	-	0.70	-	0.22	0.34	-
Detect limit	0.32	0.16	0.13	0.35	0.09	0.15	0.15	0.05

(x 1E10 atoms/cm^2)

Table I Metal contaminants (B18-1.5keV, 1E16/cm2 equivalent.)

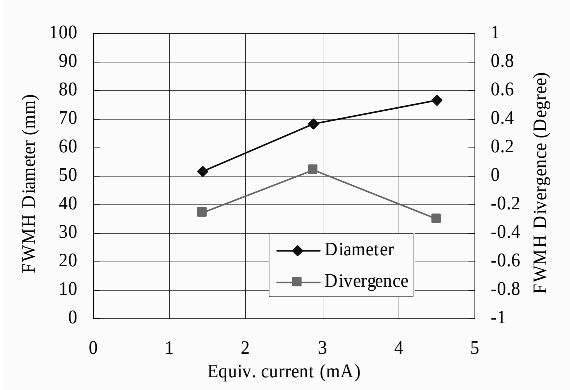
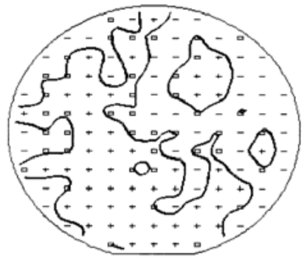


Fig.4 FWMH horizontal beam diameter and horizontal divergence (B18 - 0.5keV equivalent)



TW mean value 886 with unif. 0.28% (1 sigma)

Fig.5 Implantation uniformity, TW measurement (B18 - 0.5keV-4.5mA equivalent @ 1E15/cm^2, 0/0)

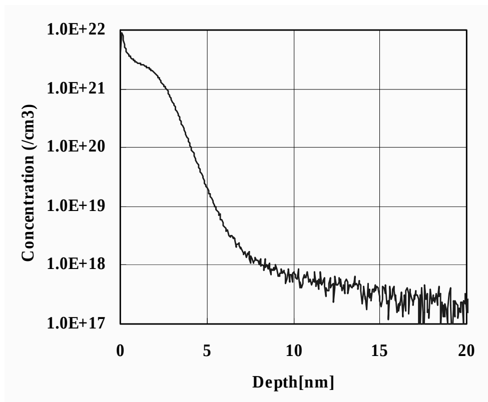


Fig.6 As implanted SIMS profile (B18 - 0.2keV equivalent @ 1E15/cm^2, 0/0)

Beam current (µA, equivalent)	TW	Rs (Ohm/sq.) [SPE 600C° 30s]
900	862	1628
2700	883	1575
4500	886	1574

Table II TW value and Rs VS. beam current (B18-0.5keV, 1e15/cm2 equivalent.)