

# Arsenic Clustering and Precipitation Analysis in Ion-implanted Si Wafers by X-ray Absorption Spectroscopy and SIMS

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The technological need for high electrical conductivity in shallow junctions requires doping with impurities (e.g., As, B, P) above equilibrium limits by ion-implantation. Sustained high level carrier concentration, even after subsequent thermal annealing treatments used by very large-scale integrated technology, is essential. One important emerging problem in doping above the solid solubility level is the formation of impurity clusters or precipitates causing electrical deactivation of the dopant. Therefore, information on the local structure around the impurity atom is of crucial importance to probe this problem. Extended X-ray Absorption Fine Structure Spectroscopy (EXAFS) being capable of probing: the short range order in crystalline and amorphous materials; one element at a time provides information on the number, distance and chemical identity of the neighbors of the main absorbing atom. In this study we have used EXAFS and SIMS to obtain clustering information in As-implanted Si wafers. CZ (001) Si wafers were first implanted by As<sup>+</sup> at 100 keV to a dose of 1x10<sup>15</sup>/cm<sup>2</sup> followed by a second As<sup>+</sup> implantation at 30 keV with doses of 2x10<sup>15</sup>/cm<sup>2</sup> and 1x10<sup>16</sup>/cm<sup>2</sup>. Figure 1 is a plot of the SIMS concentration depth profile and the corresponding UT-MARLOWE simulation for the as-implanted sample indicating the regions where the As-concentration is above the solid solubility level. The coordination numbers (N) and the nearest-neighbor distances (R) to As atoms in the first shell are extracted from non-linear least square fits to the back-Fourier Transformed EXAFS data. Some of our results are shown in Figure 2, and listed in Table I. When As precipitates as monoclinic SiAs, the nearest-neighbor distances and coordination numbers are ~2.36 Å and ~3, as opposed to ~2.40 Å and ~4 when As is substitutional. The EXAFS results are not only accurate in indicating the dose and the annealing conditions where the precipitation/clustering of As starts, but also provide information on the ratio of the substitutional vs. cluster/precipitate form As in the samples.

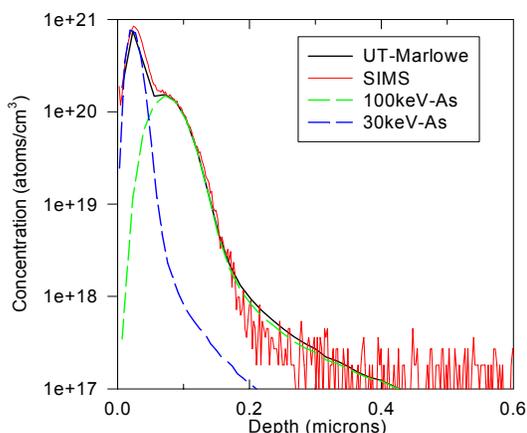


Figure 1

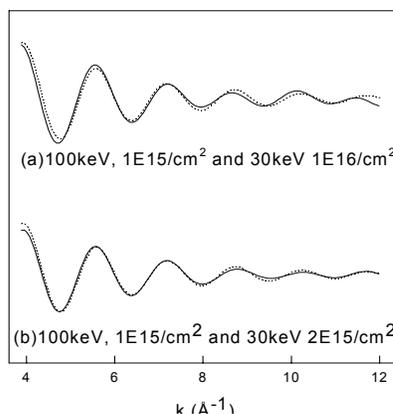


Figure 2

Table I. First Shell back-FT fit results

Sample	R(Å)	N	Structure of As
(a) 100keV, 1E15/cm <sup>2</sup> and 30keV 1E16/cm <sup>2</sup>	2.38	3.27	Cluster/precipitate
(b) 100keV, 1E15/cm <sup>2</sup> and 30keV 2E15/cm <sup>2</sup>	2.40	3.98	Substitutional