Rapid Thermal Implant Annealing using Cold Wall and Hot Wall Systems

Woo Sik Yoo[1], Takashi Fukada[1], Tsuyoshi Setokubo[2], Kazuo Aizawa[2], Jiro Yamamoto[2] and Ryuichi Komatsubara[3]

[1] WaferMasters, Inc., 246 East Gish Road, San Jose, CA 95112 U.S.A.
[2] NEC Hiroshima Limited
7-10 Yoshikawa Kogyodanchi, Higashi Hiroshima, Hiroshima, 739-0198 Japan
[3]Tokyo Electron Ltd, 3-6 Akasaka 5-chome, Minato-ku, Tokyo, 107-8481, Japan

Rapid thermal annealing (RTA) has became the preferred implant annealing method. A very short time annealing at higher temperature with a very fast ramp up/down rate ("spike anneal") has been introduced as an effective implant annealing method to electrically activate implant species with the least amount of diffusion during the annealing process. The process window of the spike anneal is very narrow because it strongly relies on temperature measurement/ control accuracy in a wide temperature range (room temperature ~1150°C) during a very short period of annealing time (<1s). For the successful formation of shallow junctions in mass device production environment, a wide annealing process window for a low sheet resistance and an abrupt dopant profiles is required. Fundamental understanding of damage recovery, electrical activation and dopant diffusion during implant anneal is necessary.

In this study, RTA of $^{75}As^{+}$ implanted Si wafer (200mm in diameter) with various implant energies and doses was annealed using a lamp-based RTA system and a single wafer rapid thermal furnace (SRTF) system under 1 atm N_2 atmosphere to mainly understand electrical activation and dopant diffusion phenomena. The implant energy and does were varied in the range of 3keV~70keV and $1x10^{15}$~$1x10^{16}$ atoms/cm^2, respectively. Annealing characteristics of $^{11}B^{+}$, $^{49}BF_2^{+}$ and $^{31}P^{+}$ implanted Si wafers were also investigated in terms of electrical activation and dopant redistribution after annealing. Sheet resistance and its uniformity of implanted wafers were measured after annealing under various conditions. Change in depth profiles of implant species was investigated using the secondary ion mass spectroscopy (SIMS).

In the initial stage of annealing, dopant nearly symmetrically diffuses both surface and bulk directions and maximum dopant concentration gradually decreases with time. Consequently, the dopant concentration near surface increases initially and decreases due to the one way diffusion into bulk with the increase of annealing time. The behavior of sheet resistance of implant annealed wafers found to be complex due to the interaction between electrical activation and dopant diffusion. The authors were able to find a wide implant annealing process window by slightly lowering annealing temperature from typical "spike anneal" conditions. Dopant diffusion and electrical activation mechanisms will be discussed at the conference.

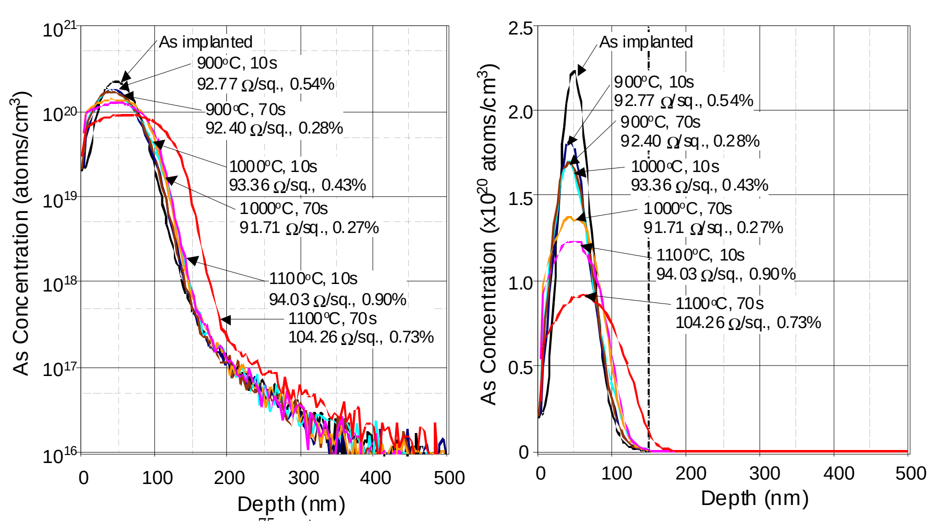

Fig. 1. SIMS depth profiles of $^{75}As^{+}$ implanted wafers after annealing using a lamp-based RTA system. ($^{75}As^{+}$ 70keV, $1x10^{15}$atoms/cm^2)