Formation Mechanism of Plateau, Rapid Fall and Tail in Phosphorus Diffusion Profile in Silicon Based on the Pair Diffusion Models of Vacancy Mechanism and Interstitial Mechanism

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Experimental P diffusion profile in Si with a constant P surface concentration of 3×10^{20} cm^{-3} at 900℃ under an inert atmosphere is shown in Fig. 1.[1)] The abscissa is $x/\sqrt{t}=\lambda$, where x is the distance from a specimen surface and t is the diffusion time. The profile has the plateau, rapid fall and tail.

Yoshida *et al*.[2,3)] studied P diffusion in Si based on the pair diffusion models of the vacancy mechanism and the interstitial mechanism. They obtained the effective P diffusion coefficient from the P diffusion equation, then proposed the limiting process of P diffusion. Based on these, the formation mechanism of the plateau, rapid fall and tail is studied.[3,4,5)]

P diffuses predominantly by the interstitial mechanism.[6)] Therefore the basic process of P diffusion is the diffusion of (PI), where I and (PI) denote self-interstitials and P-I pairs.

In the high P concentration region, excess I is generated by the dissociation of (PI) and the limiting process of P diffusion depends on whether or not excess I is controlled. That is, [1] if the concentration of excess I decreases relatively due to the effect of the decrease in quasi I formation energy, or [2] if excess I is removed by the recombination with vacancies, P diffuses fast and the plateau is formed; if not, P diffuses slowly and the rapid fall is formed.

In the tail region, the P concentration is low and the limiting process of P diffusion is the basic process of P diffusion or the diffusion of (PI). Excess I generated in the high P concentration region diffuses into the tail region and I is supersaturated there. Therefore the concentration of (PI) increases, resulting in the fast diffusion of P and the formation of the tail.Two methods, [1] and [2], were described above for the control of excess I. To investigate which of them actually occurs is a problem in future.

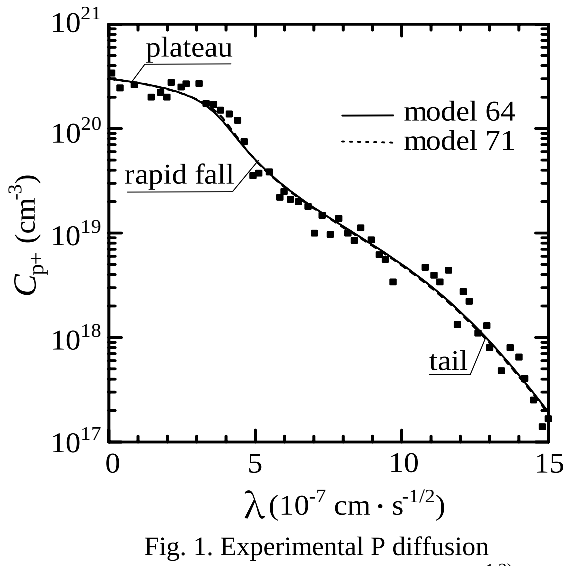

Fig. 1. Experimental P diffusion profile and its simulation.[1,3)]

1) M. Yoshida, E. Arai, H. Nakamura and Y. Terunuma: J. Appl. Phys. **45** (1974) 1498.
2) M. Yoshida, M. Morooka, M. Takahashi and H. Tomokage: Jpn. J. Appl. Phys. **39** (2000) 2483.
3) M. Yoshida and S. Tanaka: Jpn. J. Appl. Phys. **41** (2002) 5493.
4) M. Morooka and M. Yoshida: Res. Bull. Fukuoka Inst. Tech. **36** (2003) 9.
5) S. Tanaka, M. Yoshida, M. Morooka and M. Takahashi: Res. Bull. Fukuoka Inst. Tech. **36** (2004) 207.
6) T. Shimizu, T. Takagi, S. Matsumoto, Y. Sato, E. Arai and T. Abe: Jpn. J. Appl. Phys. **37** (1998) 1184.