Shallow donor complexes formed by high temperature diffusion of magnesium in silicon

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Recently awakened interest to interstital magnesium in silicon has been triggered by new hopes for applications in quantum photonics, fundamental properties of Mg-related isolated and pairing donor centers [1-3] – studies enabled by further development of high temperature diffusion doping technology in silicon [4-6]. While isolated neutral double Mg donor and its singly ionized state remain as a prime target for potential applications, other electrically active centers occur to be formed by diffusion doping and can influence optoelectronic properties of magnesium doped silicon.

Up to ten series of shallow Mg-related complexes, which energy spectra are similar to those of well-known hydrogen-like donors, have been found in silicon doped by high temperature diffusion followed by a rapid cooling [7]. These new donors are observed in the low temperature infrared absorption spectra of Si:Mg crystals, in the range from 30 to 95 meV, well below the spectrum of an isolated neutral double Mg donor. The variation of the set of Mg-related shallow donors observed in different samples, obtained at almost identic diffusion conditions, suggests competing kinetic processes of decomposition of a solid solution of magnesium in a silicon crystal, occurring right after the high-temperature stage of diffusion.

We point on an analogy between the observed shallow donors associated with Mg and the so called thermal donors in silicon, which are extensively studied and related to the presence of interstitial oxygen in silicon crystals [7].

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