Rapid Thermal Processing and the Engineering of Intrinsic Point Defect Profiles and Silicon Materials

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Rapid Thermal Processing (RTP) at temperatures greater than about 900C and in particular above about 1150C can have important effects on the distributions of intrinsic point defects in silicon wafers. These point defect distributions, in turn, can have enormous and sometimes extremely useful effects on important materials properties of bulk silicon wafers. This paper discusses the uses of RTP for the engineering of installed intrinsic point defect profiles in silicon wafers and their uses in silicon manufacturing technology and advanced IC applications. Such processes form the basis of the so-called Magic Denuded Zone (MDZ) technology [1-3] for the programming of ideal oxygen precipitation behavior into silicon wafers.

During RTP, the concentrations of intrinsic point defects in silicon wafers can be dynamically and very rapidly altered by Frenkel pair generation and recombination, interstitial injection from the wafer surfaces during oxidation, nitridation effects and transport and recombination at the wafer surfaces. The final profile that results in a wafer following a given RTP process cycle can depend on a combination of all these effects. Though their influence over these effects, many aspects of RTP processing can be important to the resulting intrinsic point profile in a wafer. Process soak temperature, ambient gases, the presence of surface films and the cooling rate all play a crucial role in the engineering of a specific point defect profile. This paper discusses quantitatively the various mechanisms through which the concentration profiles of intrinsic point defects are manipulated during the various stages of RTP. Through a wide variety of experiments investigating these phenomena, a great deal has been learned about the high temperature properties of the intrinsic point defects and their binding and release by impurities into less mobile species at somewhat lower temperatures [4].

Practically speaking only vacancies can be frozen into silicon wafers following RTP. Silicon self-interstitials play an important role in events leading up to the installation of a vacancy profile but are themselves too fast to be frozen into a thin wafer, even under RTP conditions. Vacancies are slower that interstitials by about an order of magnitude. Nonetheless, the cooling rates routinely achieved by RTP (typically ¿ ca. 20 K/s) are important for freezing useful concentrations of vacancies into a thin wafers. Vacancies are an extremely useful tool in silicon materials engineering. At concentrations exceeding about 10 12 cm 3, they come to dominate the nucleation of oxygen precipitates in Czochralski (CZ) silicon. Below this critical value normal oxygen precipitation behavior is observed. Properly utilized this bimodal material performance characteristic can be used to create layers of material having different defect performance properties. This is the core of the idea behind the MDZ wafer.

References

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