Complex Boron Redistribution Kinetics In P$^+$ Doped Polysilicon/Nitrogen-Doped-Silicon Bi-Layers

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Abstract:

Strongly doped polysilicon is a key element of today's advanced very-large-scale-integration (VLSI) technology. To continue scaling down P+ polysilicon gates of metal-oxide-semiconductor (MOS) integrated circuits, it is necessary to create very shallow junctions with strong-concentrations of electrically active boron (B). Two related processes limit the realization of this goal: (i) the enhanced redistribution of the B during the thermal post-implantation annealing and (ii) the formation of electrically inactive B clusters and B precipitates. The use of low thermal annealing temperatures and thin nitrogen-doped-silicon (NIDOS) layer have been proposed to avoid the doping depletion of P+ polysilicon gate at the oxide interface, which is one of the major performance limitations in the standard advanced MOS circuits.

The aim of this work is to develop a fundamental understanding about the complex B redistribution process into in-situ strongly doped P+ polysilicon/NIDOS bi-layers. Our goal is mainly to understand the instantaneous kinetics of B clustering, trapping, segregation and transport via the layers interface.

We have investigated the complex phenomenon of B transport mechanisms via the silicon bi-layers interface. It concerns the instantaneous kinetics of B transfer, clustering, trapping and segregation during thermal post-implantation annealing. Silicon bi-layers of in-situ strongly doped B (P+) polysilicon and NIDOS, obtained by low pressure chemical vapor deposition (LPCVD) at 480°C, have been used. To avoid long redistributions, thermal annealing was carried out at relatively low-temperatures (600°C and 700 °C) for various durations ranging between 30 minutes and 2 hours. To investigate the experimental secondary ion mass spectroscopy (SIMS) doping profiles, a redistribution model well adapted to the particular structure of bi-layers and to the effects of strong-concentrations has been established. The good adjustment of the simulated profiles with the experimental SIMS profiles allowed a fundamental understanding about the instantaneous physical phenomena giving and disturbing the complex redistribution profiles.