Cluster Ion Beam Processing

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As shrinking the size of electronic, magnetic and photonic devices, it is urgent to address crucial material-related issues: interconnect materials, thin gate oxides, processing for ultra-fine structure and ultra-shallow junction formation. This project addresses two of the challenges, ultra-shallow junction and ultra-smooth processing with cluster ion beam.

For shallow implantations, a boron cluster with ten boron atoms ($B_{10}H_{14}$) is used. As the energy of individual boron atom is almost 1/10 of the total energy of $B_{10}H_{14}$ ion, boron atoms can be implanted into the very shallow region. Also, since a cluster contains 10 boron atoms, the total ion dose can be reduced by 1/10 of the B+ implantations. Therefore, cluster ion implantation is a quite efficient method for the ultra-shallow implantation. The cluster ion implantation is successfully demonstrated to fabricate a 40nm PMOSFET as shown in figure. This device has shown better electrical characteristics than current state-of-art technology.

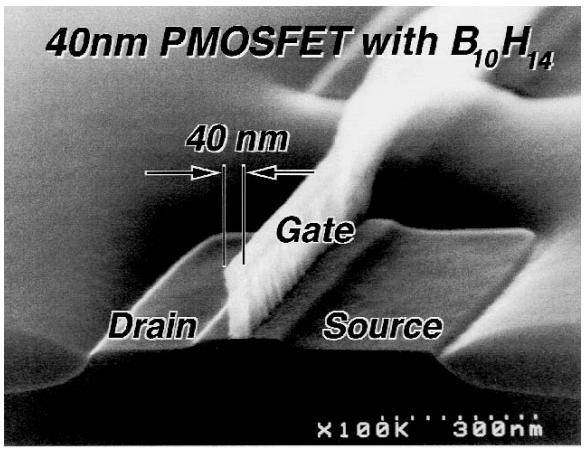

Fig. 13: SEM image of 40nm PMOSFET fabricated with $B_{10}H_{14}$ implantation.

As the impact process of cluster ion is completely different from that of monomer ion impact, defect reaction kinetics induced by cluster ion implantation have to be understand. The purpose of this project is to find the mechanism of these defects reaction kinetics from dose, energy and heat treatment dependence of defect formation. This new knowledge will be used to define an enhanced process window.

Another application of the cluster ion beam is surface smoothing. There are huge requirements to smooth various substrates or structures, where mechanical polishing cannot be employed. Cluster ion beam polishing is a low-damage and is easy to control polishing or etching conditions compared to the mechanical polishing. The smoothing with cluster ion beam is employed for various materials, such as poly-Si waveguide, giant magnetoresistive device, multi-layer optical filters, GaN films or diamond films.