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ABSTRACTS

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XTEM Study of Ni Gettering to H-Implantation-Induced Cavities in SOI Material

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For high speed, low power, complementary metal oxide semiconductor (CMOS) devices, SOI (silicon-on-insulator) has many advantages over bulk Si[1]. SIMOX (separation-by-implantation-of-oxygen) is the most widely used commercial SOI material. The manufacturing process utilizes high dose of oxygen implantation into silicon at elevated temperature followed by annealing at above 1300°C. Transition metal impurities, which are detrimental to integrated circuits, may contaminate the SIMOX wafers during the oxygen implantation, high temperature annealing and other handling processes Nanocavities generated by He or H implantation have been proposed to getter Cu and Fe in SIMOX.[2,3] Nickel is a common impurity in IC processes, and its high diffusivity and reactivity make it highly deleterious, but the gettering of Ni to nanocavities in SIMOX has not been demonstrated. In this study, we investigate the gettering of Ni impurities to the H-implantation-induced cavities in SIMOX by cross-sectional transmission electron microscopy (XTEM) and secondary ion mass spectrometry (SIMS).

The SIMOX wafer was prepared by implanting 5×10^{17} O^+cm^{-2} into an n-type (100) Si at 70keV at a substrate temperature of 680°C, followed by annealing at 1300°C for 6 hours in Ar+0.5%O_2. To investigate the gettering of Ni to the cavities in SIMOX, $2\times10^{15}cm^{-2}$ Ni was first implanted into the top Si layer at 70keV at room temperature, followed by 50kV, $3.5\times10^{16}cm^{-2}$ H implantation into the silicon substrate beneath the BOX (buried oxide) layer. The wafers were annealed at 1000°C for 2 hours in a nitrogen atmosphere to form cavities at the projected range of H ions and redistribute the Ni impurities The microstructure of the samples was examined by XTEM using a Philips JEM-400EX microscope SIMS measurements were performed to acquire the Ni in-detph profiles

XTEM study indicated that the thickness of the top Si and BOX is 90nm and 125nm, respectively After annealing at 1000°C for 2 hours, cavity band has formed along the H^+ projected range of 540nm from the sample surface and the amorphous Si caused by the Ni implantation evolved into a polycrystalline structure composed of $NiSi_2$ and polycrystalline silicon. In the meantime, some nickel impurities diffused through the buried oxide layer and were gettered by the nanocavity band. $NiSi_2$ precipitates can be observed both in the nanocavities and at the residual defects created by H implantation. The microstructure of Ni precipitate depends on whether there are cavities nearby Without cavities in the vicinity, dislocations are observed in the neighborhood of the precipitate, whereas no dislocation is detected around the precipitate when there are many nanocavities in the neighborhood The precipitation and gettering behavior can be explained by the gettering of Si interstitial to the cavities and lowering of the nucleation barrier The SIMS measurement of this 1000°C annealed sample indicates that $7\times10^{14}cm^{-2}$ Ni has been trapped by the cavity band

1 J P Colinge, Silicon-on-Insulator Technology, Materials to VLSI, Kluwer Academic Pub., Boston (1991).
2 W Skorupa, N Hatzopoulos, R. A. Yankov, and A. B. Danilin, Appl. Phys. Lett 67, 2992 (1995).
3 R A Yankov, N. Hatzopulos, W. Skorupa, and A B Danilin, Nucl. Instru. Meth. B, 120, 60 (1996).

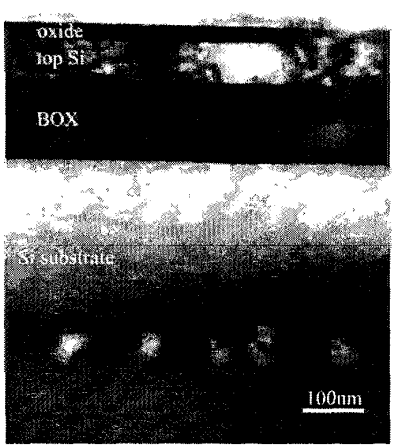

Fig 1 XTEM image of the Ni , H implanted and 1000°C annealed SIMOX. Cavities have been formed beneath the BOX layer.

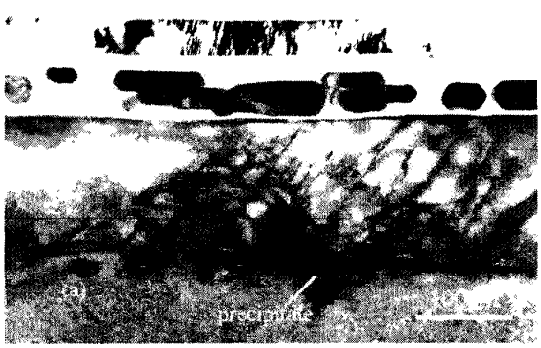

Fig.2 XTEM image of the Ni. H implanted and 1000°C annealed SIMOX, showing a big Ni precipitate together with dislocations