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High Speed C-MOS IC Using Buried SiO_2 Layer Formed by Ion Implantation

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MOS devices similar to SOS structure were fabricated utilizing a buried SiO_2 layer formed by oxygen ion implantation into silicon for the purpose of device isolation (this technology will be referred to as SIMOX, the abbreviation of Separation by Implanted Oxzgen).

A transition layer, which is the silicon region above the buried SiO_2 layer, is required to grow epitaxial silicon layer. Based on consideration of the transition layer and the values from the table[1)], given by B.J.Smith, oxygen ions were implanted into silicon substrate under conditions of an implantation energy of 150 KeV and a dose of 1.2X 10^{18} ions/cm^2. Electron diffraction pattern of the transition layer showed the fine Kikuchi lines in the diffraction pattern after annealing at 1150 °C for 2 hours.

Infrared spectra of implanted SiO_2 layer showed the well known absorption peaks for thermally grown SiO_2 after annealing above 900 °C for 1 hour. The other properties of implanted SiO_2 layers had become equivalent to that of the thermally grown ones by post-implantation annealing.

Field effect mobilities of holes and electrons in epitaxially grown silicon were 240 and 610 cm^2/Vs for 5 V gate bias respectively. These values are equivalent to those of the bulk type devices. These are shown in Fig.1.

Gated p^+-n junction diodes were fabricated in the silicon islands which were completly surrounded by the buried and thermally-grown SiO_2 layers. A typical diode whose ratio of W/L was 40 μm/40 μm exhibited excellent leakage-current characteristics as shown in Fig.2. The current was only 1 X 10^{-12} A for 10V reversed applied voltage at 0 V gate bias.

Figure 3 shows a cross-sectional view of MOSFET/SIMOX fabricated in this work. The thickness of the gate oxide and the hight of the silicon island were 700 Å and 0.5 μm , respectively. The operational properties of 21-stage CMOS/SIMOX ring oscillator having 3.1 μm effective chnnel length are exhibited in Fig. 4. The propergation delay time and the dissipation power were 0.83 ns/stage and 0.33 mW/stage respectively, for 5 V operation of the oscillator.

This high speed operation can be attributed to the good monocrystalline state of the epitaxially-grown silicon layers and to the reduction of the parasitic capacitance by the buried SiO_2 layer.

One of the interest features of SIMOX is that the short channel effect of the CMOS fabricated in this work was not observed as far as the effective channel length comes to 1.8 μm, as shown in Fig. 5.

Reference

1) G.Dearnary, et al. : Ion Implantation, 1973, North-Holland Pub.

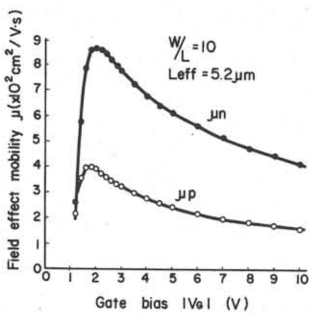

Fig. 1 Dependence of field effect mobility on gate bias.

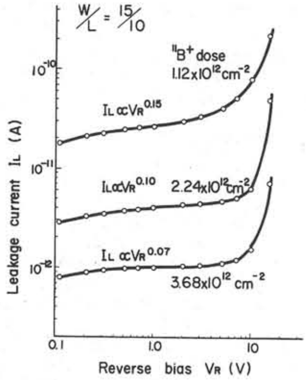

Fig.2(a) Reverse characteristics of gated n^+-p junction diodes.

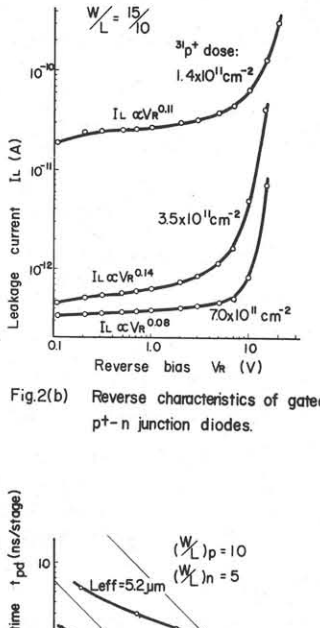

Fig.2(b) Reverse characteristics of gated p^+-n junction diodes.

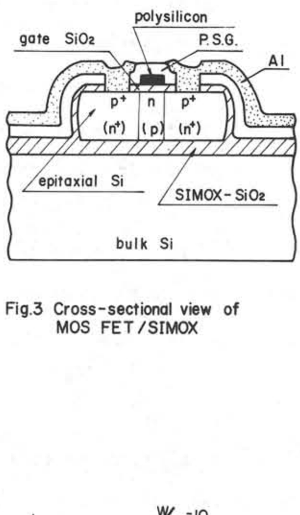

Fig.3 Cross-sectional view of MOS FET/SIMOX

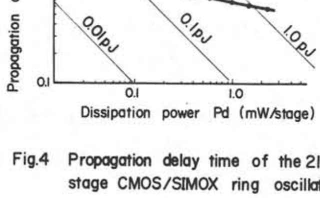

Fig.4 Propagation delay time of the 21-stage CMOS/SIMOX ring oscillator as a function of dissipation power.

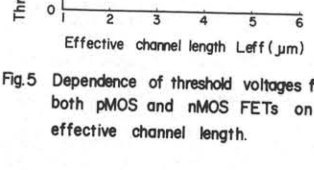

Fig.5 Dependence of threshold voltages for both pMOS and nMOS FETs on the effective channel length.