A-4-4 Improvement of channel mobility in SOS/MOSFETs by laser annealing

Y. Kobayashi, T. Ikeda, M. Nakamura, and T. Suzuki
Hitachi Research Laboratory., Hitachi Ltd.
Hitachi, Ibaraki, 319-12

INTORODUCTION Silicon-on-Sapphire (SOS) technology is currently used in low-power high-speed integrated circuits. However, there are some problems with SOS technology that remain to be solved, such as residual stress and a high density of crystal defects. These problems degrade the electrical properties of MOSFETs. Recently, laser annealing techniques have been applied in an effort to improve the crystalline quality of silicon layers.[1,2] The authors have reported that the crystalline quality of SOS can be improved by Q-switched pulse ruby laser annealing.[3,4] This paper reports on the use of laser annealing to increase channel mobility in SOS/MOSFETs.

EXPERIMENTS SOS wafers consisted of 0.4 μm thick (100)-oriented silicon layers on $(1\bar{1}02)$ sapphire substrates grown at 1020°C by pyrolyzing silane (SiH_4). The SOS wafers were exposed from the silicon layer side to a 25 ns pulse from a ruby laser (wave length = 6943 Å, beam diameter = 10 mm) with an out-put energy density of 1.3 J/cm^2. Each wafer was exposed 3 times. Al-gate n-channel MOSFETs, which were ring type FET, were fabricated with standard thermal oxidation and thermal diffusion techniques. The thickness of the gate oxide film was 800 Å. The gate length and the gate width were 20 and 723 μm, respectively.

RESULTS Fig.1(a) and Fig.1(b) show typical I_D-V_D characteristics of MOSFETs fabricated on unannealed and laser annealed layers, respectively. Fig.2 shows the gate voltage dependence of channel mobility. Channel mobility in the laser annealed SOS/MOSFET is increased about 30 % over that in unannealed SOS/MOSFET. Fig.3 shows scanning electron microscope photographs of etched silicon surfaces after MOS fabrications. The defect density in the laser annealed SOS/MOSFET is lower than that in the unannealed SOS/MOSFET. The stress in the silicon layers were investigated with laser Raman spectroscopy. This investigation showed that the residual stress in the as-grown silicon layer is compressive stress and that in the laser annealed silicon layer is tensile stress. However, thermal treatment caused the residual stress in the laser annealed silicon layer to become compressive stress. Therefore, the increase in channel mobility that was observed seems to be the result of a reduction in crystal defect density caused by the laser annealing.

CONCLUSION Q-switched pulse ruby laser annealing causes a reduction in cryatal defect density, and this reduction produces about 30 % increase in the channel mobility of SOS/MOSFET.

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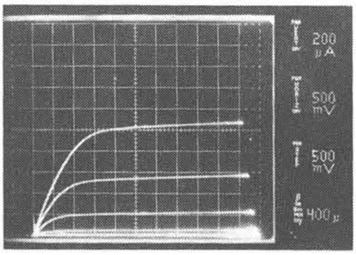
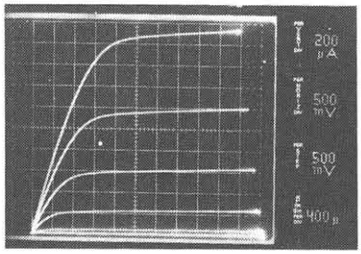


a) Unannealed SOS/MOSFET



b) Laser annealed SOS/MOSFET

Fig. 1 I_D-V_D characteristics of unannealed and laser annealed SOS/MOSFET

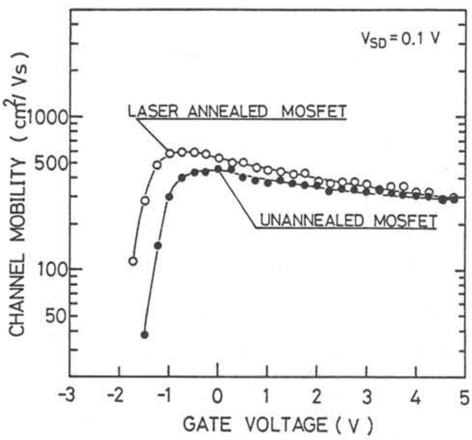
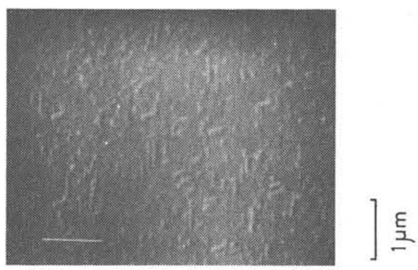
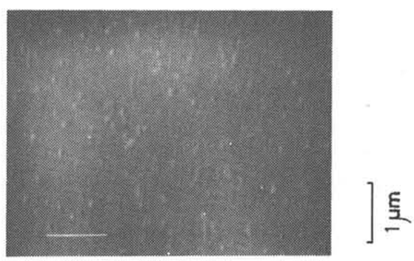


Fig. 2 Gate voltage dependence of channel mobility



a) Unannealed surface



b) Laser annealed surface

Fig. 3 SEM photographs of etched silicon surfases after MOS fabrication