C-3-8 LN

XeCl Excimer Laser Annealing used in the Fabrication of Poly-Si TFTs

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A technique for fabrication Si TFTs (thin film transistors) at a low temperature has advantages in the fabrication of VLSI devices as well as in the fabrication of large devices in which TFTs fabricated on a substrate with a low melting point are usually employed. This paper presents for the first time a technique for the fabrication of poly-Si TFTs at very low temperature by XeCl excimer laser annealing.

In the present process, to fabricate poly-Si film at a low temperature which has excellent electrical properties, hydrogenated amorphous silicon (a-Si:H) thin film deposited on TEMPAX glass was irradiated at room temperature by a XeCl excimer laser (308nm) having a pulse duration of 35 nsec. Because the absorption coefficient of the a-Si:H is 1×10^{6} cm^{-1}(1) at 308nm, the laser energy is absorbed within 200A from the surface of the film. When irradiated, therefore, a-Si:H thin film is not only crystallized without heating a glass substrate, but the crystallized film still contains a considerable amount of hydrogen at the grain boundaries. In this way, localized hydrogen atoms effectively passivate the grain boundaries and improve the electrical properties of the crystallized film.

Mo gate n-channel TFTs were fabricated in the crystallized Si film on a TEMPAX glass substrate at processing temperatures below 260°C. Figure 1 shows a schematic cross-section of the TFT. A 600A-thick Si-N layer and a 1000A-thick a-Si:H layer were deposited on the substrate by plasma CVD at 260°C. The a-Si:H layer was crystallized by annealing with a XeCl excimer laser using 70 pulses with an intensity of 185mJ/cm^2 irradiated in vacuum. After the poly-Si and Si-N islands were defined by etching with CF_4 plasma, 200A-thick Si-N and 1500A-thick SiO_2 layers were deposited by plasma CVD at 260°C for gate insulators. Next, a 6000A-thick Mo layer was deposited by sputtering and the gate electrode was defined by etching. 130keV P^+ ions were implanted in the source and drain regions to a dose of 2×10^{15} cm^{-2}. In order to activate the implanted impurities, the sample was irradiated by the XeCl excimer laser using 15 pulses with an intensity of 185mJ/cm^2. Conductivity of the n^+ region was about 50 Scm^{-1}. After contacts were opened, a 3000A-thick Al layer was evaporated and the source and drain electrodes were difined by etching.

Figure 2 and Figure 3 show the drain current vs. the drain voltage characteristics of the poly-Si TFT fabricated by XeCl excimer laser annealing and the drain current vs. the gate voltage characteristic, respectively. The effective electron mobility derived from these characteristics was 96 cm^2/V.sec. This value was much larger than that of conventional TFTs which has been fabricated in poly-Si films deposited by CVD or MBD at about 600°C. The leakage current between source and drain was 5×10^{-9} A (6.3×10^{-9} A/μm).

From these results we conclude that the XeCl excimer laser annealing open a way to a new successful technique for low temperature fabrication of Si devices.

Reference

(1) G. D. Cody, C. R. Wronsky, B. Abeles, R. B. Stephens and B. Brooks, Solar cells, 2(1980)227

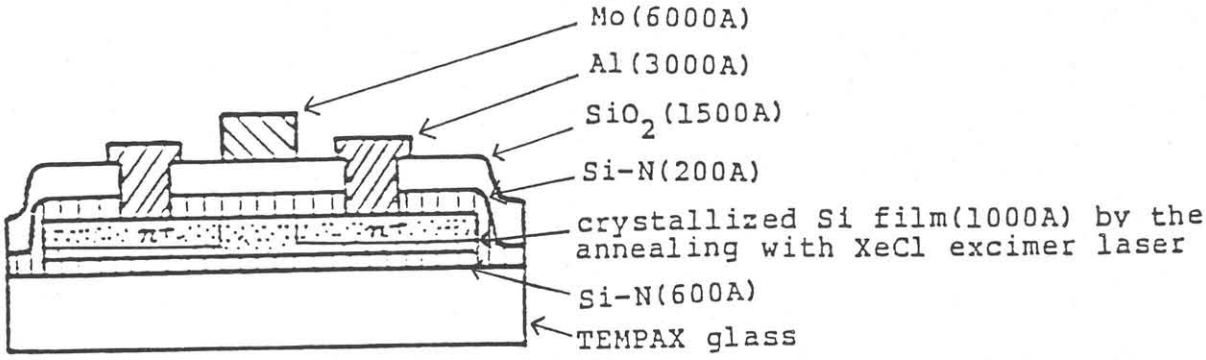

Fig. 1 Schmatic cross section of the Poly-Si TFT fabricated by the XeCl excimer laser annealing

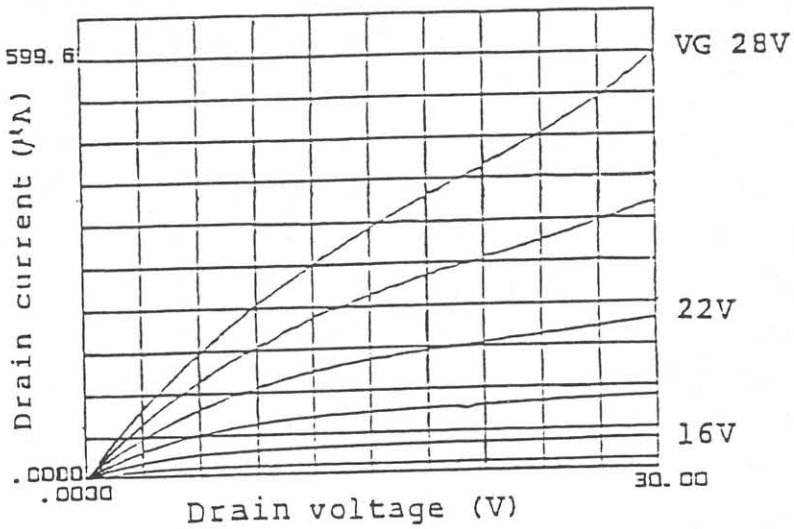

Fig.2 Drain current vs. drain voltage characteristics of the poly-Si TFT with a channel length of 20μm and channel width of 160μm.

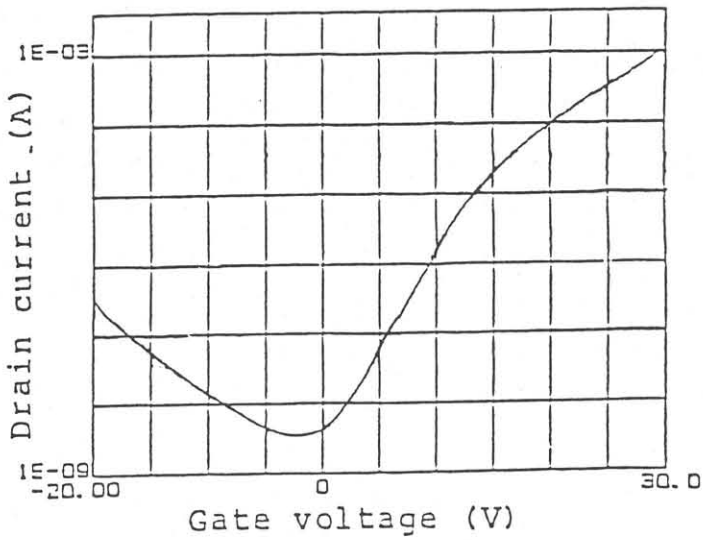

Fig. 3 Drain current vs. gate voltage characteristics at a drain voltage of 30 V.