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High-Performance LTPS-TFTs Fabricated by Continuous Wave Laser Annealing

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1. Abstract

In this work, a novel activation and crystallization technology of poly silicon thin film has been studied by continuous wave laser. CW laser activation technology would be first investigated. The material properties of doped poly-Si thin films by CW laser activation were analyzed by four point probe measurement system and secondary ion mass spectrometer (SIMS). Then, CW laser crystallization technology would also be studied. As a result, high performance p-channel and n-channel CW laser crystallization (CLC) TFTs have been demonstrated.

2. Introduction

Low temperature polycrystalline siliconlicon TFTs fabricated by excimer laser annealing (ELA) had been applied to high performance AMLCDs and AMOLEDs. However, excimer laser crystallization has some essential drawbacks such as complex optical system, high facility cost, troublesome maintenance, poor output energy stability and narrow process window for producing large grains. Recently, a stable diode pumped solid state (DPSS) continuous wave (CW) laser crystallization was applied to the fabrication of high-performance polycrystalline silicon TFTs on non-alkali glass substrate [1]-[2]. Laser activation technology seems to be the most promising method to active the dopant with low thermal budget because the silicon was heated, melted and reformed without heating the glass, resulting in a very high efficiency. But the activation technology of CW laser was rarely studied. In this work, dopant activation and Si thin film crystallization by continuous wave laser has been fabricated for high-performance TFTs.

3. Experiments

Fig. 1 displays the process flows of LTPS-TFTs fabricated by CW laser annealing. At first, amorphous silicon thin films were deposited by pure SiH_4 with low-pressure chemical vapor deposition (LPCVD) at 550℃ on quartz substrates. Then, laser crystallization was performed by CW laser (λ=532nm). During the laser irradiation, the samples were located on a substrate in air and substrate was maintained at room temperature. After that, active region were defined by RIE. Then, a 1000Å TEOS oxide layer was deposited as gate insulator by PECVD following 2000Å amorphous silicon layer was deposition as gate electrode by LPCVD. Next, the amorphous silicon thin films and the gate insulator were etched by RIE. A self-aligned phosphorous implantation with a dosage of 5×10^{15} cm-2 was performed to form source and drain regions. 3000 Å-thick TEOS passivation oxide layers were deposited and the implanted dopants were activated. After contact opening by RIE, metallization were carried out to complete the fabrication of CW laser annealing LTPS-TFTs. No post plasma treatment was carried out on these devices. For comparison, conventional top-gate ELC LTPS-TFTs with laser energy in SLG region and laser shots of 100 were also fabricated. Moreover, the efficiency of dopant activation by CW laser was analyzed by four point probe measurement system and secondary ion mass spectrometer.

4. Results and discussion

Fig. 2 and Fig. 3 show the sheet resistance of samples after excimer laser and CW laser activation by four-point probe system, respectively. According to these figures, for CW laser, if the scanning rate was slower, lower sheet resistance was attained attributed to the longer annealing time. The sheet resistances of samples after CW laser and excimer laser activation were summarized in Table I. Fig. 4 shows the redistribution profiles of phosphorus after excimer and continuous wave laser annealing. Dopant redistribution profiles in the polycrystalline silicon thin films by CW laser were as uniformly as excimer laser one. Therefore, CW laser activation was a low thermal-budget and high efficiency method.

Fig. 5 and Fig. 6 show the typical transfer characteristics of CW laser crystallization TFTs with channel lengths of 2 um. Field effect mobility of 192 cm2/V-s for n-channel and 92 cm2/V-s for p-channel could be achieved, respectively. Several important electrical characteristics of the CW laser TFTs were also summarized in Table II.

5. Conclusions

High-performance LTPS TFTs has been fabricated by continuous wave laser annealing method. Low sheet resistance of 92 Ω/□ was observed by CW laser dopant activation and high field-effect-mobility was attained by CW laser Si thin film crystallization. Hence, continuous wave laser annealing was promising for the system on panel (SOP) application in the future.

Acknowledgements

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References

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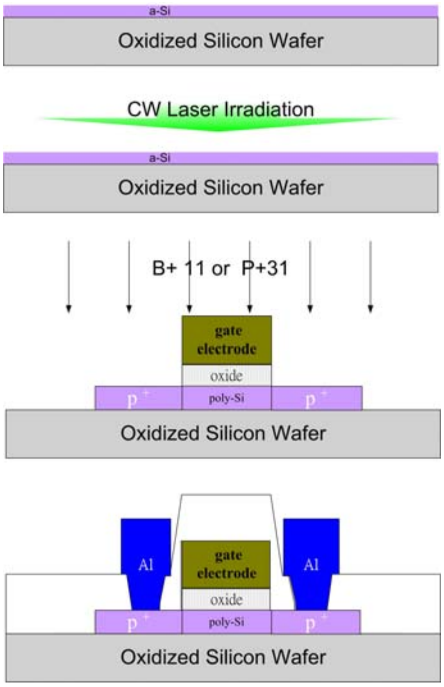

Fig. 1 Process flow of CW laser LTPS TFT

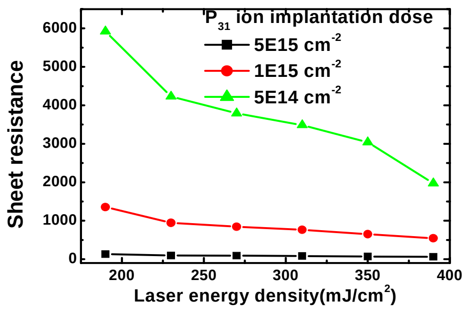

Fig. 2 The sheet resistance of phosphorus-doped poly-Si films after excimer laser activation.

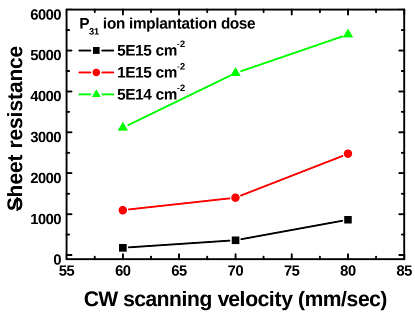

Fig. 3 The sheet resistance of phosphorus-doped poly-Si films after CW laser activation.

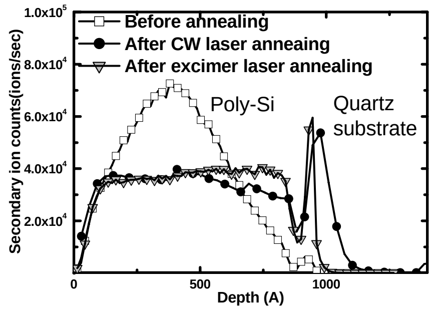

Fig. 4 redistribution profiles of phosphorus after excimer and continuous wave laser annealing.

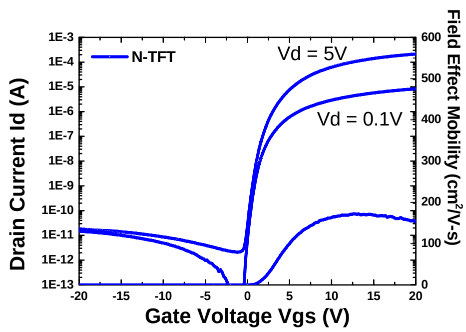

Fig. 5 N-channel TFT.

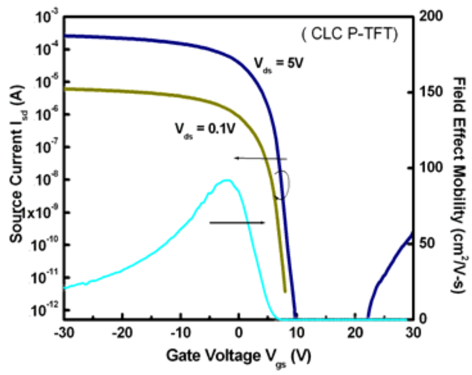

Fig. 6 P-channel TFT.

Table I

Sheet resistance Ω/□	P_{31} 5E15
CW laser	92.0
Excimer laser 390 mJ/cm^2	63.4
RTA 650c 60s	121
FA 600c 24hrs	103

Table II

TFT Structures	Threshold Voltage (V)	Field-effect-Mobility (cm^2/Vs)	Subthreshold Swing (V/dec)	On/off current ratio (10^7)
Conventional ELC	3.3	114	1.13	2.5
Proposed n-type CWC	1.5	189	0.25	9.1
Proposed p-type CWC	5.6	95	0.61	210