High Performance Poly-Si TFT (μ>290cm^2/Vsec) Direct Fabricated on Plastic Substrate below 170^{o}C

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Abstract

We present the characterization of poly-Si TFT fabricated below 170^{o}C on plastic substrate using excimer laser crystallization of Xe sputtered Si films. Gate insulator with a breakdown field exceeding 8 MV/cm was deposited by using inductively coupled plasma CVD. Finally, we successfully fabricate TFT with a electron field-effect mobility value greater than 290 cm^2/Vsec.

1. Introduction

AMLCD (Active Matrix Liquid Crystal Display) using a-Si:H TFT (Thin Film Transistor) is now the technology of choice for displays in laptop computers and desktop PCs, and is presently extending its range into the TV and mobile phone FPD (Flat Panel Display) markets. Although TFT devices using a-Si as the active channel are sufficient for driving AMLCD pixels, they could not be used in other applications requiring higher drive current because of their low mobility (μ_n < 1 cm^2/Vs, μ_p < 10^{-2} cm^2/Vs). As a result, much attention has been directed into research and development of LTPS (low temperature poly-Si) TFTs.

In order to crystallize a-Si precursor films for LTPS TFT applications, ELA (Excimer Laser Annealing) has been extensively employed. Excimer laser irradiates a short pulse of high energy which is efficiently absorbed at the thin silicon film, allowing melting of the Si film while minimally heating the glass substrate.

In future applications requiring flexible displays, plastic substrates will be expected to replace glass substrates [1-3]. As the thermal tolerance of plastic is even lower than that of glass, ELA is the best approach not only for crystallizing a-Si film but also for activating dopants such as phosphorus and boron. However, obstacles arise at virtually every step of the poly-Si TFTs fabrication process on plastic because of its low glass temperature. In this study, we describe a method of successfully fabricating high performance TFT on plastic substrates.

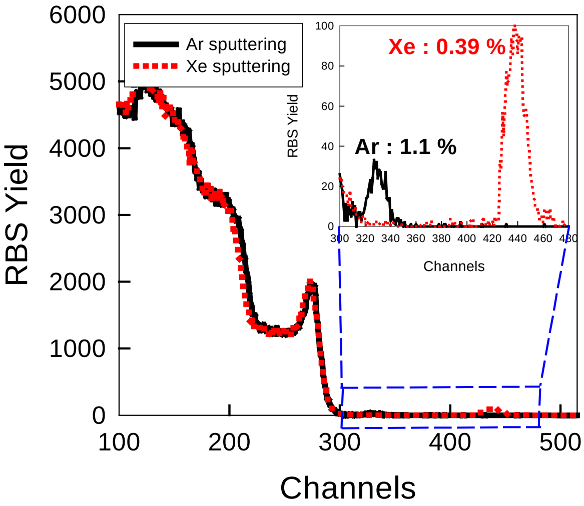

Fig.1 Gas concentration in Si film sputtered with Ar and Xe gas

2. Results and Discussions

a-Si film as a precursor of active layer was deposited by using sputtering with Xe gas in order to reduce gas concentration in Si film compared with conventional sputtering process with Ar gas. As shown in Fig. 1, gas concentration for sputtering with Xe gas is lower than that for with Ar gas, because it is not so easy for Xe atom to incorporate in film during sputtering process due to heavier mass compared with Ar gas. This low gas concentration makes it possible to crystallize by excimer laser annealing without Si film delamination from gas evolution[4]. Figure 2 shows SEM image of the poly-Si film with large grains. The average grain size is 0.5 um and maximum as larger as 1.0 um [5].

For gate insulator, SiO_2 film was deposited by using inductively coupled plasma chemical vapor deposition (ICP-CVD) in order to reduce substrate temperature during deposition. Figure 3 shows the variation of current density of SiO_2

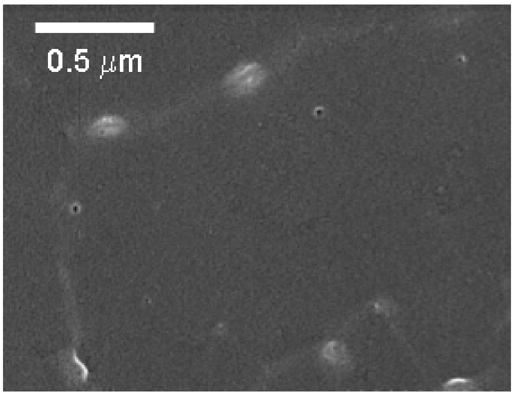

Fig.2 SEM image of laser crystallized Si film

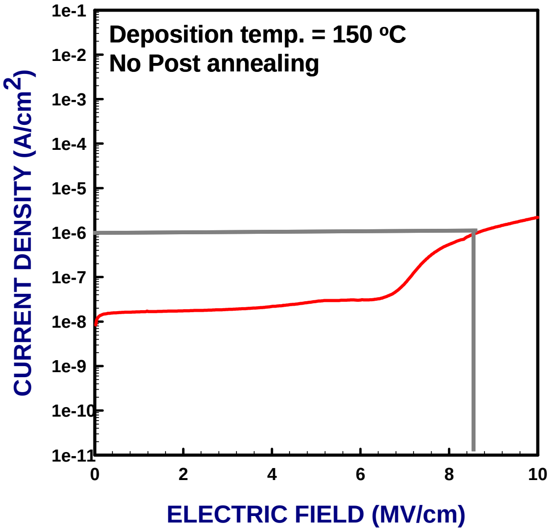

Fig. 3 Current density vs electric field characteristics of SiO_2 film deposited by using ICP-CVD at $170^{o}C$

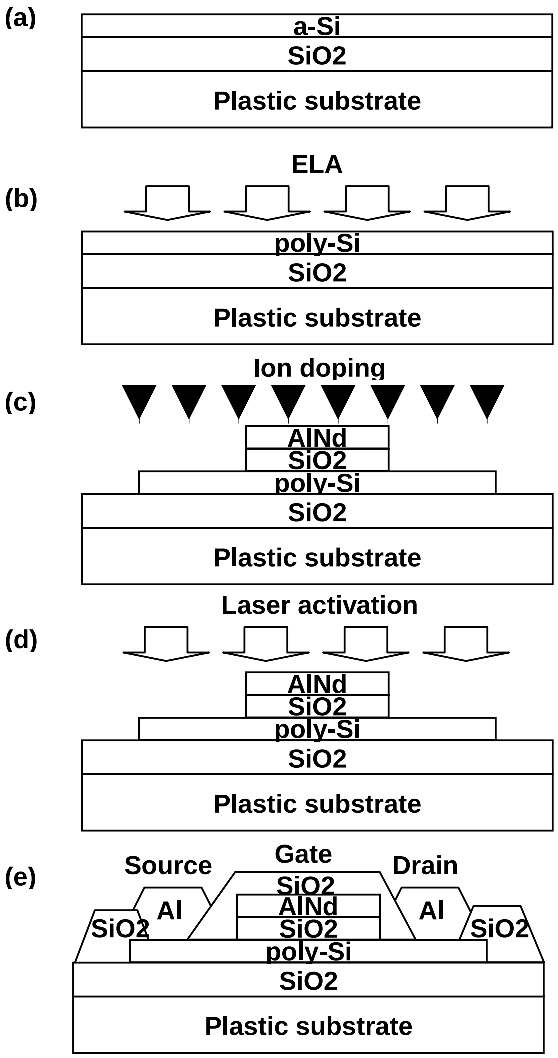

Fig. 4 Schematic process flow for TFT fabrication on plastic substrate

film as a function of electric field. Even though SiO_2 film was deposited below 170°C, the breakdown field was measured at 8.6MV/cm which is large enough to realize transistor devices [6].

Figure 4 indicates schematic process flow of TFT fabrication. On barrier coated PES substrate, Xe sputtered Si film was crystallized by ELA method. Gate insulator and metal were formed by ICP-CVD and DC sputtering respectively. After gate patterning, source and drain were performed by ion implantation followed by laser activation. The measured field-effect mobility was 258cm^2/Vsec and subthreshold swing is 0.1V/dec (Fig.5). The electrical characteristics of fabricated TFTs are summarized in Table I. The TFT characteristic was measured without any kind of post treatment including hydrogenation. Based on this TFT performance, it is possible to integrate not only pixel transistor but also functional circuit such as drive IC and DC-DC converter.

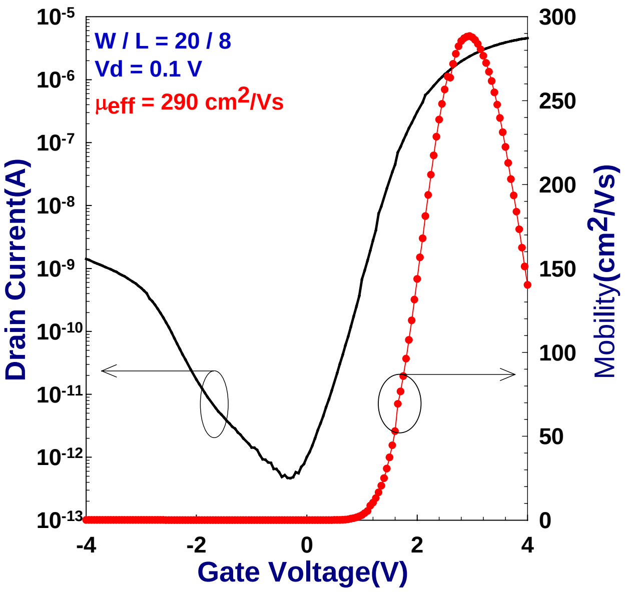

Figure 5 Log Ig-Vd transfer characteristic and field effect mobility of poly-Si TFT on plastic substrate[7] at below 170 °C

3. Summary

We successfully fabricated the high performance TFT on plastic substrate. Based on our technology, it is thought that flexible, thin unbreakable and light AMOLED display could be realized. In addition, high resolution and low power consumption display could be also fabricated by integration drive IC and DC-DC converter. Finally, it might be one of technical achievement to realize system on plastic (SOP).

Table 1 Summary of the poly-Si TFT on plastic substrate (W/L=20/8)

TFT parameters	Value (at V_{ds}=0.1V)
I_{on}/I_{off} current ratio	>$1x10^7$
Ion_max. [A]	$4.8x10^{-6}$
V_{th} [V]	2
Subthreshold Swing [V/dec.]	0.18
$\mu_{eff.}$ [cm^2/Vs]	290

4. References

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