Fabrication of the Poly-Si Thin Film Transistor on the Mica Substrate

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Abstract

A mica has been introduced as a new substrate material for the fabrication of the poly-Si TFTs. A poly-Si film is produced on the mica substrate at 550℃ by the nickel-induced crystallization and the poly-Si TFTs on the mica substrate are successfully fabricated for the first time.

1. Introduction

Polycrystalline Si (Poly-Si) thin films have been tried to fabricate by many researchers because of the increasing demands of the application to electronic devices such as thin film transistors (TFTs) for OLED and LCD. Poly-Si thin films are generally fabricated by the crystallization of amorphous Si (a-Si) thin films and many methods such as solid phase crystallization (SPC), metal-induced crystallization (MIC), and excimer laser annealing (ELA) were developed [1]. In the SPC method, it generally takes tens of hours to crystallize a-Si films even at above 600℃. This process is very simple and cheap. And, it enables to get more uniform poly-Si films in comparison with the direct-deposited poly-Si films. But, the long process time at high temperature deteriorates the substrates such as glass and plastics. In the MIC method, a-Si thin films contact with metal elements (Au, Cu, Al, Ni, Pd) on film surface to lower the crystallization time and the crystallization temperature in the SPC method, and then the crystallization is able to occur at below 600℃ [2-4].

In recent years, flexible display is one of the attractive issues in the electronic display devices. Plastic substrates are an obvious candidate for the flexible display applications. However, the plastic substrates have a few problems such as low chemical durability and low temperature resistance at below 250℃, leading to limit the process conditions of the next fabrication steps. Therefore, it requires low temperature for the production of the poly-Si.

In this work, the mica substrate is chosen for the substrate of the poly-Si TFTs. It is considered that the mica is replaceable to the plastic substrate because of its flexibility, transparency, chemical stability and relatively high temperature resistance (below 600℃) [5]. A-Si films were crystallized on the mica substrate at 550℃ for 15 hours by the MIC method using viscous Ni solution spin coating, and the poly-Si TFTs on the mica were fabricated..

2. Results

In order to examine the thermal stability of the mica substrate, each mica substrate is annealed at 500, 550, 600, 650℃ for 20 hours. Figure 1 shows the optical micrographs of the mica substrates after the annealing at the various temperatures. After the annealing below the temperature at 550℃, the surface of the mica substrate is changeless, and has no defects and no damages. However, the cracks and the worm-like bubbles are observed on the surface of the mica substrates which is annealed above the temperature at 600℃. Therefore, it is confirmed that the mica substrate has relatively higher temperature resistance than other plastic substrates.

A-Si thin film was deposited on the mica substrate by plasma enhanced chemical vapor deposition (PECVD) at 300℃ and its thickness is fixed at 100 nm. Figure 2 shows the optical micrographs of the a-Si films on mica substrate after the furnace annealing at 550℃ for 10 hours. The Ar plasma pre-treatment is performed just before the deposition of a-Si thin film. From the annealed sample without Ar plasma pre-treatment in Fig. 2(a), many defects like bubble or crack are observed. But, the clean and smooth surface of Si film can be obtained from the sample with Ar plasma pre-treatment in Fig. 2(b). It seems to be related to the low adhesion between the a-Si thin film and the mica substrate because of no dangling bonds on mica surface [6]. Therefore, this result indicates that Ar plasma pre-treatment is very effective to enhance the adhesion of the Si thin film on the mica substrate.

Figure 3 shows the XRD patterns of the crystallized samples as a function of the crystallization time at 550℃. A-Si thin films are crystallized by MIC method using viscous Ni solution spin coating, which is prepared by dissolving 0.1mol $NiCl_2$ in 1N HCl and mixing with propylene glycol. The crystallization of a-Si are progressed after the crystallization time of 5 hours and the crystallized Si thin films have a preferred orientation of Si(111). And then, a-Si thin films are completely crystallized at 550℃ for 15 hours.

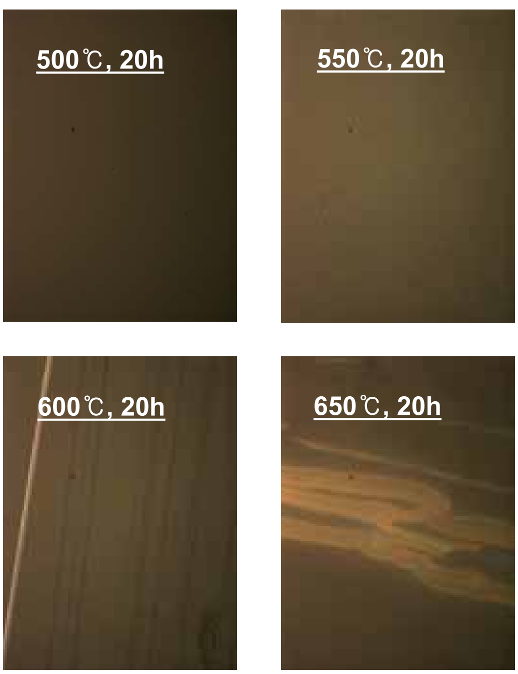

Figure 1. Optical micrographs of the mica substrates after the annealing at the various temperatures.

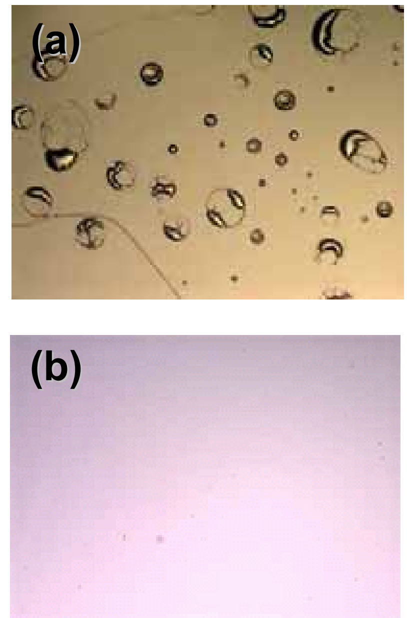

Figure 2. Optical micrograph of the annealed samples at 550℃ for 10 hours (a) without Ar plasma pre-treatment and (b) with Ar plasma pre-treatment

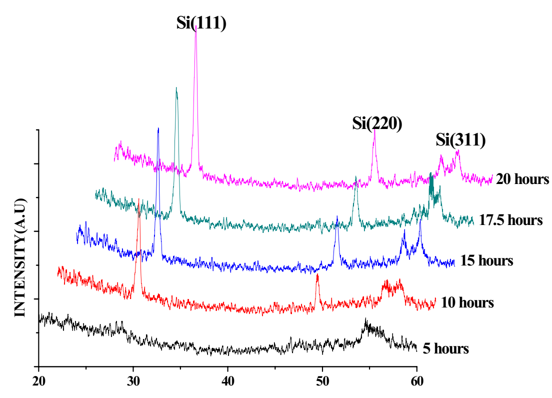

Figure 3. XRD patterns of the crystallized samples as a function of the crystallization time

The crystallized Si on the mica substrate is observed by the optical microscope (Fig. 4). It can be seen Fig. 4(a) that large crystallized regions with 1~2 µm and very small crystallites with nano-size are formed during the crystallization of the a-Si thin film. The clean and smooth surface of the fully crystallized Si thin film on the mica substrate can be seen in Fig. 4(b). This implies that it is possible to acquire the poly-Si thin films on the mica substrate by MIC method at 550℃ for 15 hour, and the mica substrates offer wider process window for the fabrication of the poly-Si TFTs in comparison with the plastic substrates. In addition, it is shown in Fig. 5 that the fully crystallized Si film on the mica substrate is transparent.

The goal of this study is to fabricate TFTs on mica substrate. Figure 6 shows that the poly-Si TFTs on the mica substrate can be successfully fabricated, which is reported in the first time.

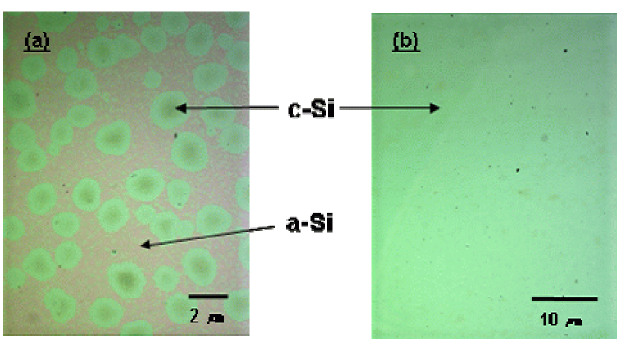

Figure 4. Optical micrographs of the crystallized Si thin film on the mica substrate

Figure 5. Image of the fully crystallized Si film on the mica substrate

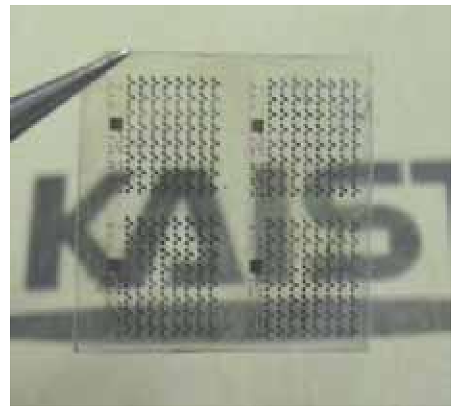

Figure 6. TFTs on the mica substrate

3. Conclusion

This study is a new attempt for the poly-Si TFTs on the mica substrate to apply the flexible display. The mica substrate has been used as the substrate material for the fabrication of the poly-Si TFTs, and it has the advantage of relatively higher temperature resistance (up to 600℃) than other plastic substrates. The poly-Si thin films on the mica substrate are successfully produced at 550℃ for 15 hours by metal-induced crystallization method using viscous Ni solution spin coating. Finally, we could fabricate the poly-Si TFTs on the mica substrate for the first time.

4. Acknowledgements

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5. References

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