Poly-Si 기판을 이용한 저온 공정 metal dot nano-floating gate memory 제작

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Fabrication of low temperature metal dot nano-floating gate memory using ELA Poly-Si thin film transistor

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Abstract : Nano-floating gate memory (NFGM) devices were fabricated by using the low temperature poly-Si thin films crystallized by ELA and the In_2O_3 nano-particles embedded in polyimide layers as charge storage. Memory effect due to the charging effects of In_2O_3 nano-particles in polyimide layer was observed from the TFT NFGM. The post-annealing in 3% diluted hydrogen (H_2/N_2) ambient improved the retention characteristics of In_2O_3 nano-particles embedded poly-Si TFT NFGM by reducing the interfacial states as well as grain boundary trapping states.

Key Words : nano-floating gate memory, poly-Si TFT, In_2O_3 metal nano-particles, annealing effects

1. Introduction

The polycrystalline silicon thin-film transistor (poly-Si TFT) has been applied in the active matrix liquid crystal display applications due to high electric field-effect-mobility and large drivability [1]. Especially, the low temperature poly-Si (LTPS) TFT is also expected to be a key devices to the development of system-on-glass (SoG) at flat panel display since it makes compact, and low power TFT LCD for mobile terminal devices [2]. Also, the metal nano-particles have some advantages such as higher density of states around the Fermi level and smaller energy perturbation. Furthermore, the metal nano-particles make the deep quantum wells between control oxide and tunnel oxide due to the difference of work functions.

In this study, we fabricated the poly-Si TFT NFGM devices by using ELA (excimer laser annealing) crystallization method and In_2O_3 nano-particles embedded in polyimide insulating layers for the applications of memory on a glass substrate.

2. Experiments

We fabricated the floating gate memory devices with In_2O_3 nano-particles on the poly-Si films crystallized by ELA method. Source/drain regions were defined before the formation of gate stacks (tunnel oxide/In_2O_3 nano-particle/ polyimide blocking insulator) to avoid the thermal damages of polyimide insulating layers by using the in-situ phosphorous doped poly-Si films. Then, the phosphorus in-situ doped poly-Si layer was partially removed to form the channel region. After formation of tunneling gate oxide with a thickness of 4.5 nm, the thermal evaporation of indium layer of 5 nm and the spin coating of polyamic acid (PAA) with a 50 nm thickness were sequentially followed. Then, the chemical reactions between indium ion and PAA for the formation of the In_2O_3 nano-particles inside the polyimide matrix occurred by the curing process. The aluminum was deposited by thermal evaporation and the gate electrode was formed. Finally, the fabricated devices were annealed in 3% diluted hydrogen (H_2/N_2) ambient at 400°C for 30 minutes to improve the electrical characteristics.

3. Results and Discussion

Figure 1 shows the structure of fabricated poly-Si TFT NFGM devices with In_2O_3 nano-particles embedded in polyimide layer. The channel length and width of fabricated NFGM is 20 μm and 10 μm, respectively.

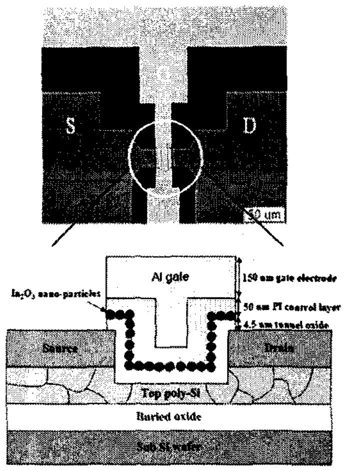


Figure 1 Structure of fabricated poly-Si TFT NFGM with In_2O_3 nano-particles in polyimide layer.

Figure 2 shows the cross-section TEM image of In_2O_3 nano-particles embedded in polyimide layer after curing process of 400°C for 1 hour. The In_2O_3 nano-particles shows the spherical shape with an average diameter of 7 nm and the particle density is about 6×10^{11} cm^{-2}.

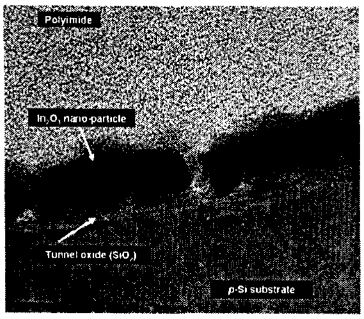
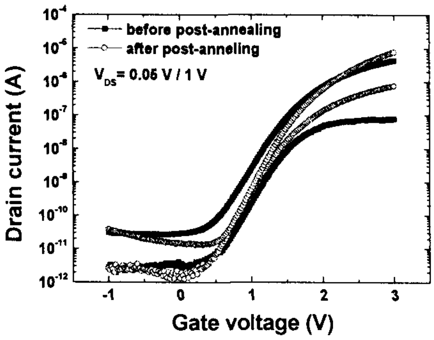
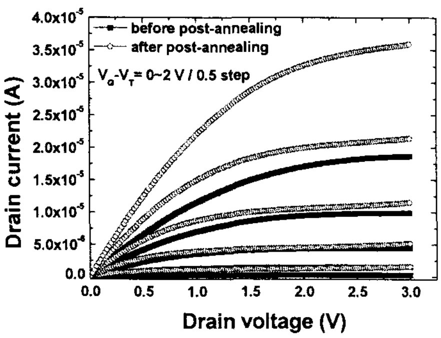


Figure 2. Cross-sectional TEM image of In_2O_3 nano-particles embedded in polyimide layer

Figure 3 shows the subthreshold characteristics and the output current characteristics of the fabricated TFT NFGM with In_2O_3 nano-particles in polyimide. It is found that the electrical characteristics are considerably improved after annealing of 3% diluted hydrogen (H_2/N_2) ambient at 400°C for 30 m. The decrease of subthreshold swing and the increases of drain current are observed in both NFGM devices fabricated on poly-Si film.



(a) I_D-V_G curves of poly-Si NFGM



(b) I_D-V_D curves of poly-Si NFGM

Figure 3. Subthreshold characteristics (a), and output current characteristics (b) of poly-Si TFT NFGM with In_2O_3 nano-particles in polyimide layer.

Figure 4 shows the retention characteristics of the fabricated NFGM devices. Although the memory window of NFGM without In_2O_3 nano-particles is less than 0.2 V, the window increases to 3.2 V by inserting the In_2O_3 nano-particles in polyimide layer. Additionally the charge retention characteristics were significantly improved by post annealing in 3% diluted hydrogen (H_2/N_2) ambient. It is considered that these improved electrical characteristics are associated with the reduction of interface traps at the tunnel oxide/polyimide interface as well as bulk traps in polyimide layer.

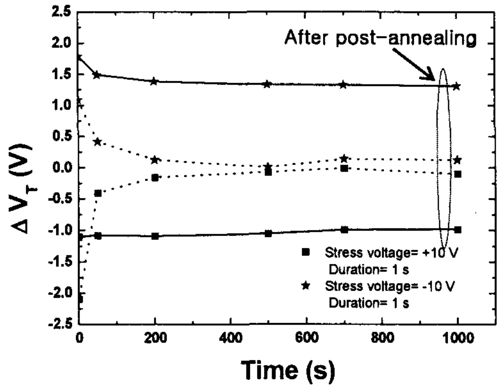


Figure 4 Retention time characteristics of poly-Si TFT NFGM with In_2O_3 nano-particles in polyimide layer.

4. Conclusions

The NFGM devices with In_2O_3 nano-particles were fabricated on poly-Si films. The In_2O_3 nano-particles have spherical shape with an average diameter of 7 nm and the particle density was about 6×10^{11} cm^{-2}. Thin SiO_2 as a tunnel oxide, In_2O_3 nano-particles as nano storages and polyimide layer as a blocking insulator were sequentially stacked on poly-Si channel. The post-annealing in 3% diluted hydrogen (H_2/N_2) ambient at 400°C for 30 m significantly improved the electrical characteristics of In_2O_3 nano-particles embedded NFGM. Therefore, Therefore, the NFGM device using low temperature processes fabricated on the poly-Si film has a potential for the SoG applications.

5. References

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[2] Y Nakajima et al. SID 04 Dig.m 2004, pp. 864-867