New Laser Crystallization for LTPS on Panel

Takashi NOGUCHI[1]*,*
Takuya ASHITOMI, Kiyoharu SHIMODA, Kimihiko IMURA, Kota NAKAO,
Charith J. KOSWATHTHAGE and Tatsuya OKADA,
University of the Ryukyus, 1 Senbaru, Nishihara, Okinawa 903-0213, Japan
Tel.:81-098-895-8680, E-mail: tnoguchi@tec.u-ryukyu.ac.jp

New Laser Crystallization using Blue Laser-Diodes is reported and discussed. As a result of the blue laser diode annealing (BLDA) scanning at 500 mm/s for 50 nm-thick Si films, remarkable crystallization occurred while maintaining the surface's smoothness not only for CVD film but also for sputtered film. By changing the laser power, the grain size can be controlled from micro-grains to large grains as well as to anisotropic long crystal grains. For the Si films of heavily phosphorus doped condition, the resistivity decreased drastically depending on the increase in the electron mobility while the high carrier concentration values were retained for the various grained structures after BLDA. High activation rate of the impurity dopant in the Si network was realized. For un-doped Si film as a channel in TFT which was fabricated by low temperature process without using ion implantation, good transfer curve was observed. A simple structure of poly Si TFTs with metal source/drain is proposed as a low cost fabrication process.

1. Introduction

LTPS TFTs have been extensively studied for AMLCD as well as for AM OLED on glass. Poly Si TFTs having high mobility and high reliability are integrated and mounted on panel not only as pixel circuits but also as peripheral circuits, and even functional sensors as SoG. Currently, functional smart panels are expected for next generation flexible displays. However, reducing the fabrication cost and the decreasing the process temperature for conventional LTPS are important issues. Poly Si TFTs fabricated with low cost, which poses high stability, are wanted. So far, we have proposed and reported BLDA as a new LTPS [1, 2]. From uniform micro-grains to large grains and even anisotropic long grains having improved electrical properties can be obtained reproducibly with keeping the Si surface smooth by adopting the BLDA technique [2], while those films are hardly controlled directly by conventional pulsed excimer laser annealing (ELA). By BLDA, crystallization of Si films on plastic substrate has also been demonstrated successfully [3].

Currently, although pulsed ELA is adopted for LTPS production, the equipment cost as well as the running cost is fairly high. BLDA system, which suits advanced LTPS process, is expected to be reduced the production cost because the smaller size of equipment as the semiconductor diode-lasers are small and can be operated stably at lower power driving without consuming the reactant gases.

2. Experimental

50 nm-thick a-Si films were deposited by r.f. sputtering using or by CVD on glass. For sputtered case, Ne gas was used as a sputtering gas [1, 3]. The two kinds of target were prepared for rather intrinsic deposition and for heavily phosphorus doped condition. The films were crystallized using BLDA with a constant power density at a speed of 500 mm/s. During the irradiation, as amorphous Si has fairly high absorbance at 445 nm in visible as well as at 308 nm in UV pulsed excimer laser (XeCl), the thin Si films are heated up and crystallized effectively near the melting point of Si. In the thin film of 50 nm thickness, the temperature gradient between top part and bottom part of Si films is very low during heating. As a result of BLDA for the impurity doped Si films, higher activation is seen by adopting Ne gas than by Ar gas. Ne atoms in Si film are effused out more easily than Ar atoms during BLDA and higher power exposure of laser is feasible for thin amorphous Si films on panel [1]. After optimizing the sputtering deposition of SiO_2 for gate insulator of high breakdown condition [4], TFTs were fabricated without ion implantation below 450℃ on glass and were evaluated.

3. Evaluation and Discussion

After BLDA at 5W for the sputtered un-doped Si films, the optical properties and the crystallinity of the Si films were evaluated using spectroscopic ellipsometry (S.E.) and Transmission Electron Microscopy (TEM) [1]. The surface morphology of Si surface was smoother than that by excimer laser annealing of conventional LTPS.

Subsequently, simple metal contact was adopted for source and drain in place of impurity doping without ion implantation. Titanium (Ti) of low work function was deposited for source and drain using vacuum evaporation. As a result, quasi-ohmic contact for electron injecting from the metal source into Si channel is realized. Fabricated TFT structure is shown in Fig.2. The obtained effective electron mobility higher than 50 $cm^2/V.s$ is comparable to the case of TFTs with impurity doped source and drain [5]. After BLDA for CVD Si film, much higher mobility than 100 $cm^2/V.s.$ with sharper gate voltage swing similar to the case of conventional LTPS can be obtained [6].

4. Summary

Basic electronic properties of Si films are evaluated and Poly Si TFTs formed by sputtering or by CVD and subsequent BLDA are discussed. By adopting the new BLDA technique, high performance TFT systems including functional sensors are expected to be integrated on glass as well as on flexible panel with reducing the fabrication cost.

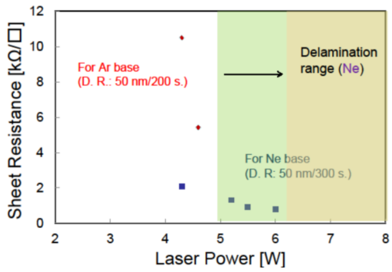


Fig.1 Sheet resistance after BLDA for sputtered Si films using Ar or Ne gas. [1]

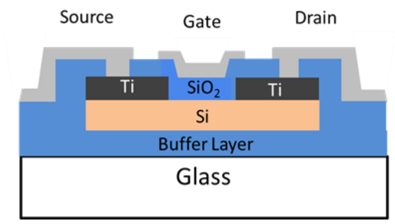
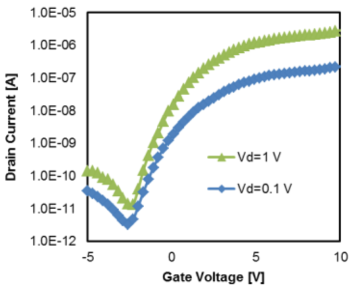
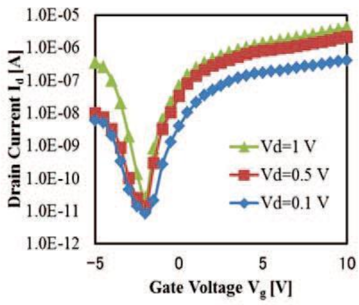


Fig. 2 Cross section of TFT of metal S/D [5].



Fig, 3 Tranfer curve of TFT with metal S/D for sputtered Si channel [5].



Fig, 4 Tranfer curve of TFT with metal S/D for CVD Si channel [6].

Acknowledgment

The BLDA was assisted by Mr. Y. Ogino in Hitachi Information & Telecommunication Engineering Co. The research was partially supported by Strategic Core Technology Advancement Program, Mr. K. Inoue (Products Support Co.), Dr. T. Itoh (Corning Japan K.K.), Dr. K. Saitoh (ULVAC Inc.), Prof. T. Mohammed-Brahim (Univ. Rennes), Prof. B.S. Bae (Hoseo Univ.) and Mr. H. Kuroki (Ryukyu allcom Co.) and othres.

References

1. T. Noguchi and T. Okada, 'REVIEW PAPER', *J. of Inf. Display*, **15**, **No. 1,** p.47 (2014)..
2. T. Noguchi, Y. Chen, T. Miyahira, J.D. Mugiraneza, Y. Ogino,Y. Iida, and E. Sahota, *Jpn. J. Appl. Phys*. **49**, 03CA10 (2010).
3. T. Okada, J.D. Mugiraneza, K. Shirai, T. Suzuki, T. Noguchi, H. Matsushima, T. Hashimoto, Y. Ogino, and E. Sahota, Jpn. *J. Appl. Phys*. **51**, 03CA02 (2012).
4. K. Imura, T. Okada, K. Shimoda, K. Sugihara, T. Noguchi1 and B.S. Bae, *Proc. of IMID 14*, **P1-44**, (2014).
5. Sugihara, K. Sugihara, K. Shimoda, K. Imura, T. Ashitomi, C. J. Koswaththage, T. Okada and T. Noguchi, *Proc. of AWAD2014*, **3A-3**, p.122, (2014).
6. K. Shimoda, T. Ashitomi, T. Okada, T. Noguchi, O. Nishikata and A. Ota, *To be presented in AMFPD2015*,