Extended Abstracts of the 1993 International Conference on Solid State Devices and Materials, Makuhari, 1993, pp. 970-971

A-Si:H TFTs Fabricated with Gated rf-discharge Plasma-CVD Technology

Kazushige Takechi, Hiroyuki Uchida, Hiroshi Hayama
Functional Devices Research Laboratories, NEC Corporation
1-1, Miyazaki 4-Chome, Miyamae-ku, Kawasaki, Kanagawa, 216, Japan
Akira Kodama, Yoshimi Watabe
3rd Thin Film Engineering Division, ANELVA Corporation
8-1, 5-Chome, Yotsuya, Fuchu-shi, Tokyo, 183, Japan

Plasma-CVD of a-Si:H is key technology in TFT-LCD manufacturing and is very important in reducing TFT-LCD cost. We deposited a-Si:H films under various conditions with gated rf-discharge plasma-CVD technology. The film properties and particle generation were evaluated quantitatively in detail. We have found that particle generation can be decreased two orders compared with conventional plasma-CVD technology, keeping both film-quality and deposition-rate high. TFTs, whose characteristics are as good as conventional TFTs, have also been fabricated with the gated rf-discharge technology. TFT electron mobility of as high as 0.8cm^2/V/sec has been achieved with faster deposition-rate about three-times than conventional plasma-CVD. Great impact on reducing TFT-LCD manufacturing cost is expected with this technology.

Gated rf-discharge plasma-CVD technology has fewer particle generation capability.[1] However, experimental results for this technology have not been reported in detail. We have actually evaluated the particle generation and a-Si:H film properties, and then fabricated a-Si:H TFTs by using this technology for the first time.

An rf-generator with gated-output capability and a pulse-generator were connected to a conventional plasma-CVD chamber(ANELVA ILV-9100). The output of the pulse-generator was used as the gate signal (the output enable signal) to the rf-generator. Figure 1 shows the gated rf-discharge plasma-CVD diagram. In the following experiment, the "on" time, during which rf-output was on, was kept constant and the "off" time, during which rf-output was off, was changed. Figure 2 shows the particle generation dependence on a-Si:H deposition rate. It can be seen that the particle generation is decreased two orders compared with the conventional cw-discharge. Figure 3 shows the a-Si:H deposition rate and hydrogen content dependence on "on" duty. The deposition rate increases up to 390Å/min to the "on" duty of the rf-output. Hydrogen content also increases to the "on" duty. From detailed analysis, this is mainly caused by the increase of the Si-H_2 bonds in the a-Si:H film. Figure 3 shows that a-Si:H films with good quality were formed at high deposition rates. We interpret the above result as follows. The lifetime of SiH_3 radicals is longer than that of SiH_n radicals. The SiH_n radicals produce much more particles than the SiH_3 radicals. With the gated rf-discharge, SiH_n radicals decrease during each rf-output "off" periods. Therefore, particle generation is suppressed drastically, and remaining SiH_3 radicals during each "off" periods contribute to form low hydrogen-content (i.e. high quality) a-Si:H films.

Channel-passivated inverted-staggered a-Si:H TFTs were fabricated. They were fabricated by conventional processes except for the gated rf-discharge plasma-CVD process. Figure 4 shows the typical V_g-I_d characteristics of fabricated TFTs. The on/off current ratio is over 10^7, that is large enough as LCD switching devices. Figure 5 shows the TFT mobility dependence on "on" duty. The TFT mobility decreases to the increase of the "on" duty. This may be due to the increase in the Si-H_2 bonds. Figure 5 shows that TFT mobility of 0.5cm^2/V/sec was obtained at the deposition rate of over 300Å/min. Furthermore, by optimizing the rf-power, the iteration frequency and "on" duty, high mobility TFT (0.8cm^2/V/sec) was achieved at the deposition rate of about 250Å/min.

As shown above, we made it clear that the gated rf-discharge technology is very effective for suppressing particle generation, quality control and high-speed deposition of a-Si:H films. It was found that film properties and TFT characteristics were controllable by such parameters as rf-power, "on" duty and iteration frequency. These results indicate that the gated rf-discharge plasma-CVD technology is very useful for the high throughput and low cost production of TFT-LCDs.

(1)Y.Watanabe, M.Shiratani, Y.Kubo, and S.Ogi, Appl.Phys.Lett. 53(14), 3 October 1988

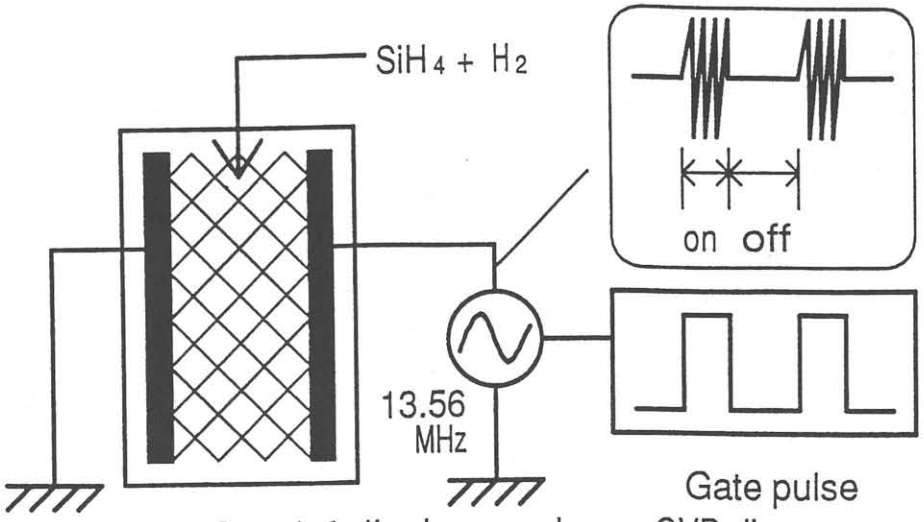

Fig.1 Gated rf-discharge plasma-CVD diagram

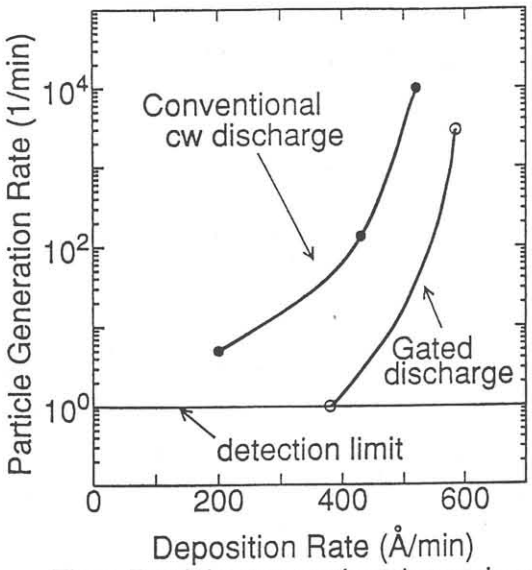

Fig.2 Particle generation dependence on a–Si:H deposition rate

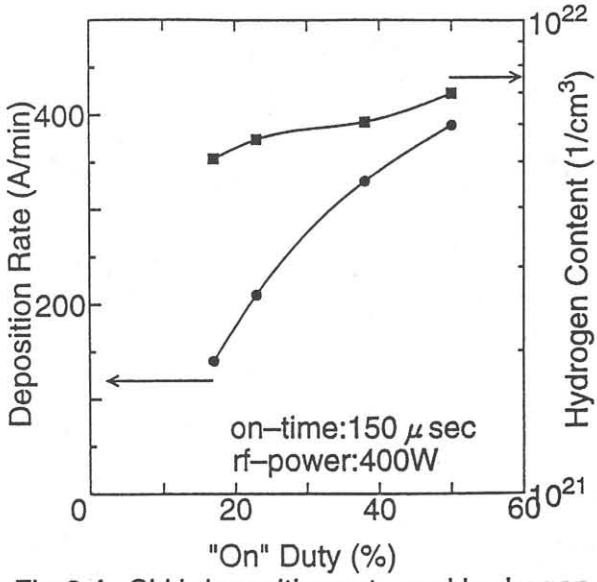

Fig.3 A–Si:H deposition rate and hydrogen content dependence on "on" duty

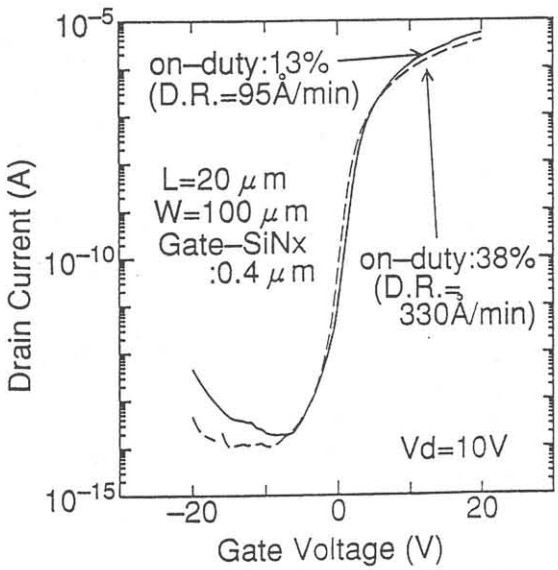

Fig.4 Vg–Id characteristics of the fabricated a–Si:H TFTs

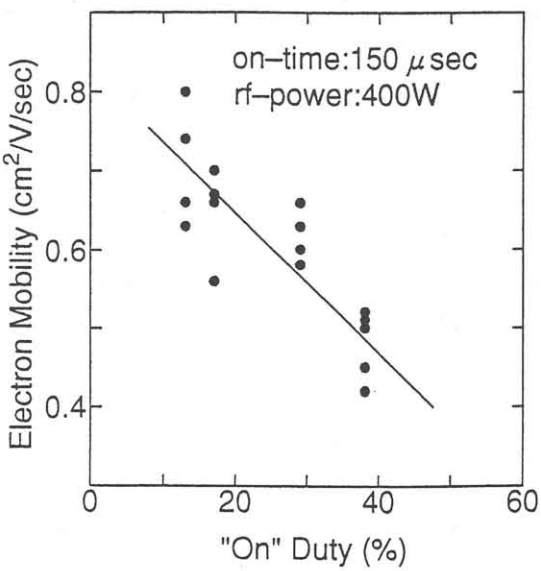

Fig.5 TFT mobility dependence on "on" duty