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Fabrication of a-Si:H TFT's by a Large Area Ion Doping Technique

Akihisa YOSHIDA, Masaaki NUKAYAMA*, Yasunori ANDOH*
Masatoshi KITAGAWA and Takashi HIRAO

Central Research Laboratories, Matsushita Electric Ind. Co., Ltd.
*Research and Development Div., Nissin Electric Co., Ltd.

Micro-processing techniques over a large area have been of great importance to fabricate large size and high density liquid crystal displays (LCD). Recently, large area doping techniques using a broad ion beam without mass separation were reported[1),2)]. We have developed a large area ion doping apparatus with a rf ion source (Fig. 1). It can be achieved to dope impurities into 32cm-sq. substrate with a maximum ion energy of 10keV at 300 C by the ion doping apparatus.

The problems associated with charge accumulation should be considered in case of thin film devices on glass substrates during ion doping. As shown in Fig. 2, we measured electrical conductivities (σ) of a-Si:H films on 10cm-sq. glass substrates doped by two types of the ion doping apparatus. The one includes only high voltage grid (single grid), and the other includes high voltage grid and grounded grid (double grid). Ion doping conditions were as follows; doping gas was 5% PH_3 in H_2, acceleration voltage (V_i) was 6kV, substrate temperature (T_s) was 300 C, and total ion dose (C_i) was $5X10^{15}cm^{-2}$. From Fig. 2, uniform doping was achieved in the case of ion doping using double grid. n^+layer with a conductivity of 10^{-4}S/cm was obtained. Double grid is effective for suppressing charge accumulation and uniform doping.

Fig. 3 shows depth profiles of ^{31}P and ^{1}H concentration of ion doped a-Si:H film determined by SIMS. We set ion doping conditions as follows; doping gas was 2% PH_3 in H_2, V_i=3kV, T_s=300'C, C_i=$5X10^{15}cm^{-2}$. Peak position of simultaneously doped ^{1}H concentration ($10^{22}cm^{-3}$) is about 50nm in depth. This value of depth is correspond to a projected range (R_p) of 3keV H^+ predicted from LSS theory[3)].

We fabricate invert staggered TFT's (Fig. 4) on 4-in. glass substrates. Source and drain contacts of TFT's are formed by ion doping technique. Thickness of passivation layer (PS) is 100nm or 250nm. Ion doping conditions were as follows; doping gas was 5% PH_3 in H_2, V_i=6kV, T_s=300'C, C_i=$1X10^{16}cm^{-2}$. V_G-I_D characteristic of TFT with PS of 100nm thick is depletion type (V_{TH}=-6V). It should be caused by simultaneously implanted hydrogen ions (R_p=110nm for 6keV H^+, predicted from LSS theory). V_G-I_D characteristic of TFT with PS of 250nm thick is enhancement type (V_{TH}=4.9V) as shown in Fig. 5. Field effect mobility (μ_{FE}) is 0.56cm^2/Vs and $I_{ON}(V_G=20V)/I_{OFF}(V_G=-5V)$ ratio is 10^7. After annealing at 265 C in N_2 for 90min., V_{TH} and μ_{FE} are unchanged and I_{OFF} decreases. We have obtained high performance a-Si:H TFT's for LCD switching devices using the large area ion doping apparatus.

References

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2) G. Kawauchi et al. : Extended Abstracts of The 37th Spring Meeting on Jpn. Soc. of Appl. Phys. No.2(1990) p.651

3) R. G. Wilson : Ion Beams with Applications to Ion Implantation, (Wiley, NY, 1973), p.270

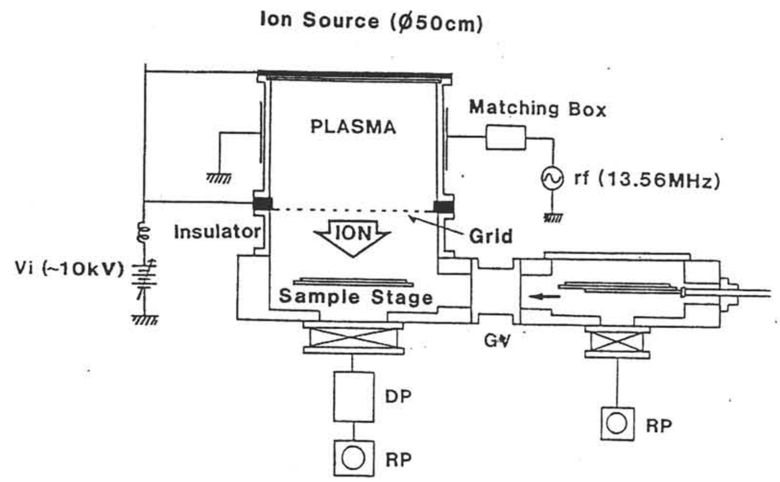

Figure 1 Schematic drawing of a large area ion doping apparatus (s with an rf ion source. A diameter of ion source is 50cm.

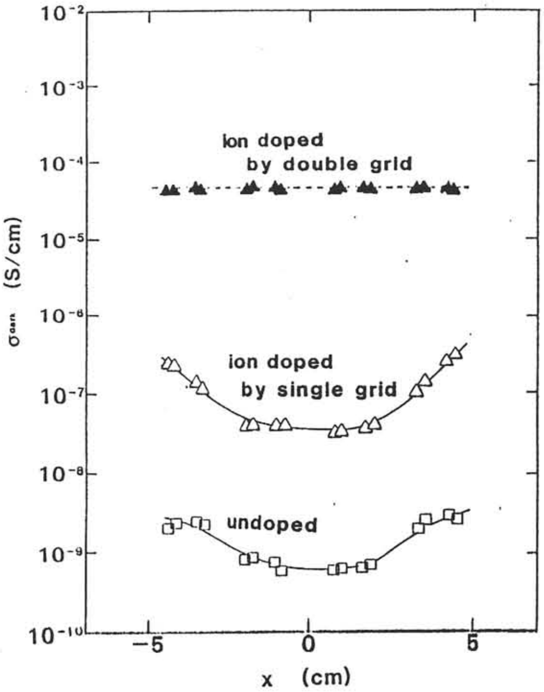

Figure 2

Electrical conductivities of undoped and iondoped a-Si:H films on 10cm-sq. glass substrate. Ion doping were performed by two types of ion accelerator; single grid (only high voltage grid) and double grid (high voltage grid and grounded grid).

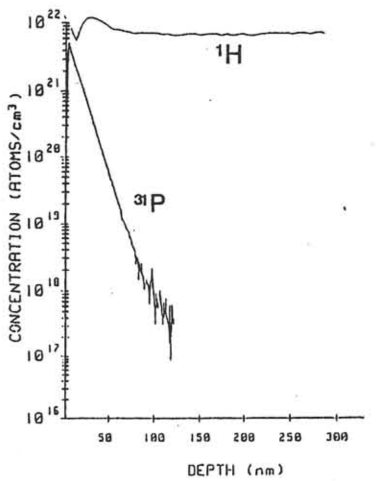

Figure 3 SIMS profiles of iondoped phosphorus and hydrogen atoms.

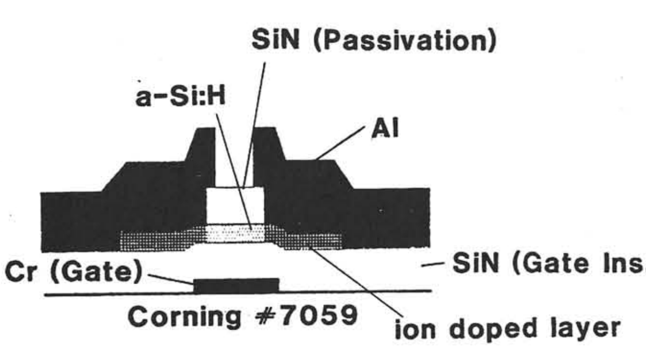

Figure 4 Cross-sectional view of fabricated TFT

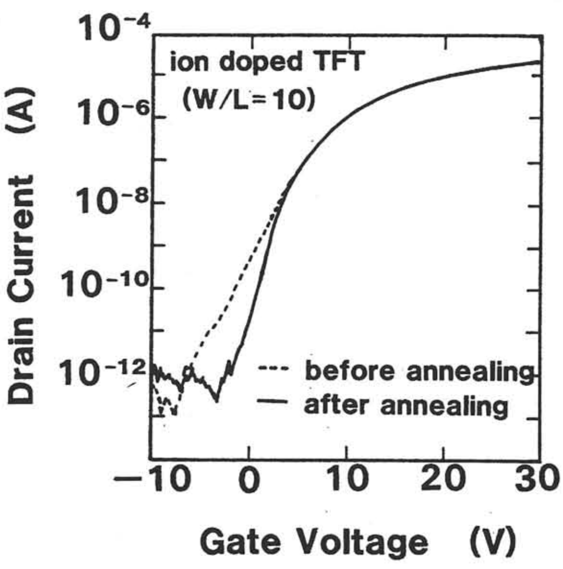

Figure 5 V_G-I_D characteristic of fabricated TFT(V_D=12V, L=10um, W=100um). V_{TH} is 4.8V and field effect mobility is 0.58 cm^2/Vs.