Th2-7

Electrical Properties of Oxide TFT with an IGZO/AlOx Stack Grown by Non-Vacuum Mist Chemical Vapour Deposition

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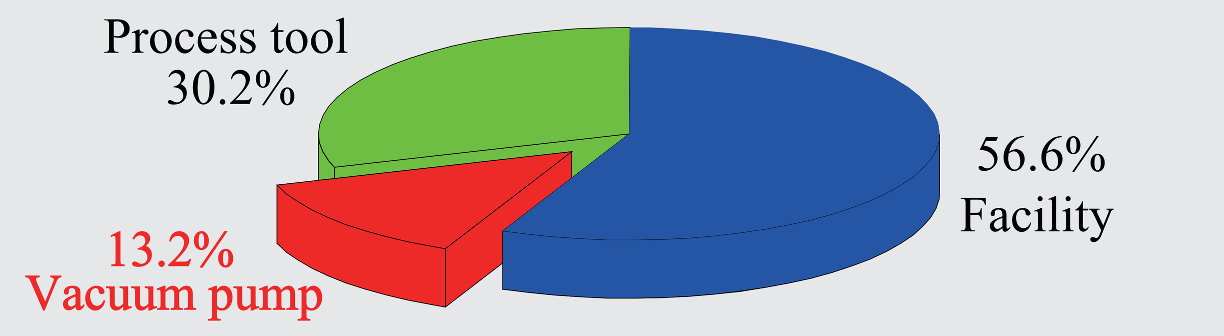
- Motivations -

The electric power ratio of semiconductor plant



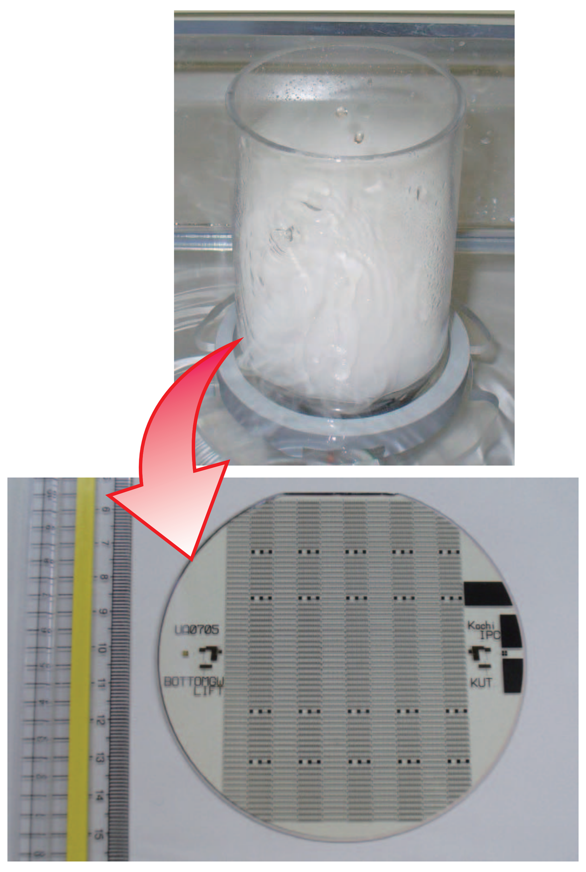
2008 ISMI workshop on Equipment Energy Reduction.

A lot of electric power is needed in order to keep vacuum state. The burdens of the environment can be directly reduced by shifting vacuum process to atmospheric pressure process.

Thus, we had attempted to convert TFT fabrication process to non-vacuum process with gate insulator and channel layer grown by mist CVD.

- Mist Chemical Vapour deposition (Mist CVD) -

A. "Stable materials" can be used as "gas"

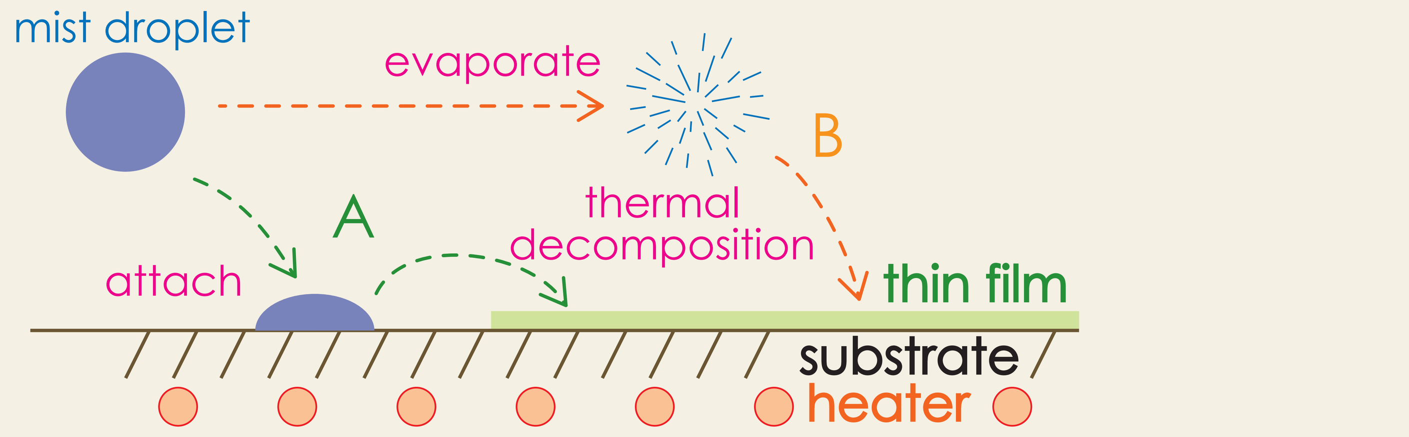


Advantage of mist method

A. "Stable materials" can be used as "gas" .
B. Selection operation of CVD and spray.
C. High experimental efficiency.
D. Less oxide-defect oxide thin film can be grown.

B. Selection operation of CVD & Spray.

A. Mist droplet directly attach to the substrate
B. Mist droplet evaporates before attaching to the substrate.



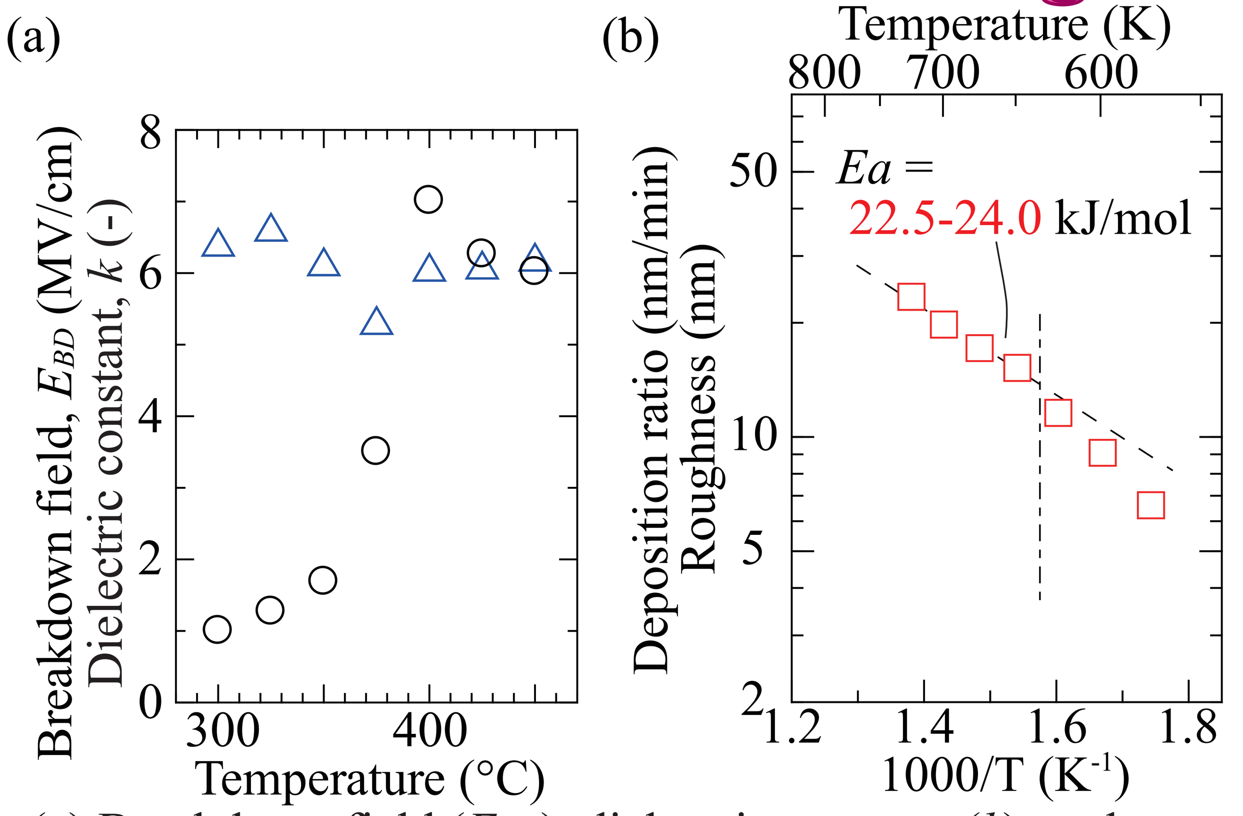
- Fabrication of AlOx and IGZO thin films grown by Mist CVD -

Table 1. Deposition conditions of AlO_x thin films

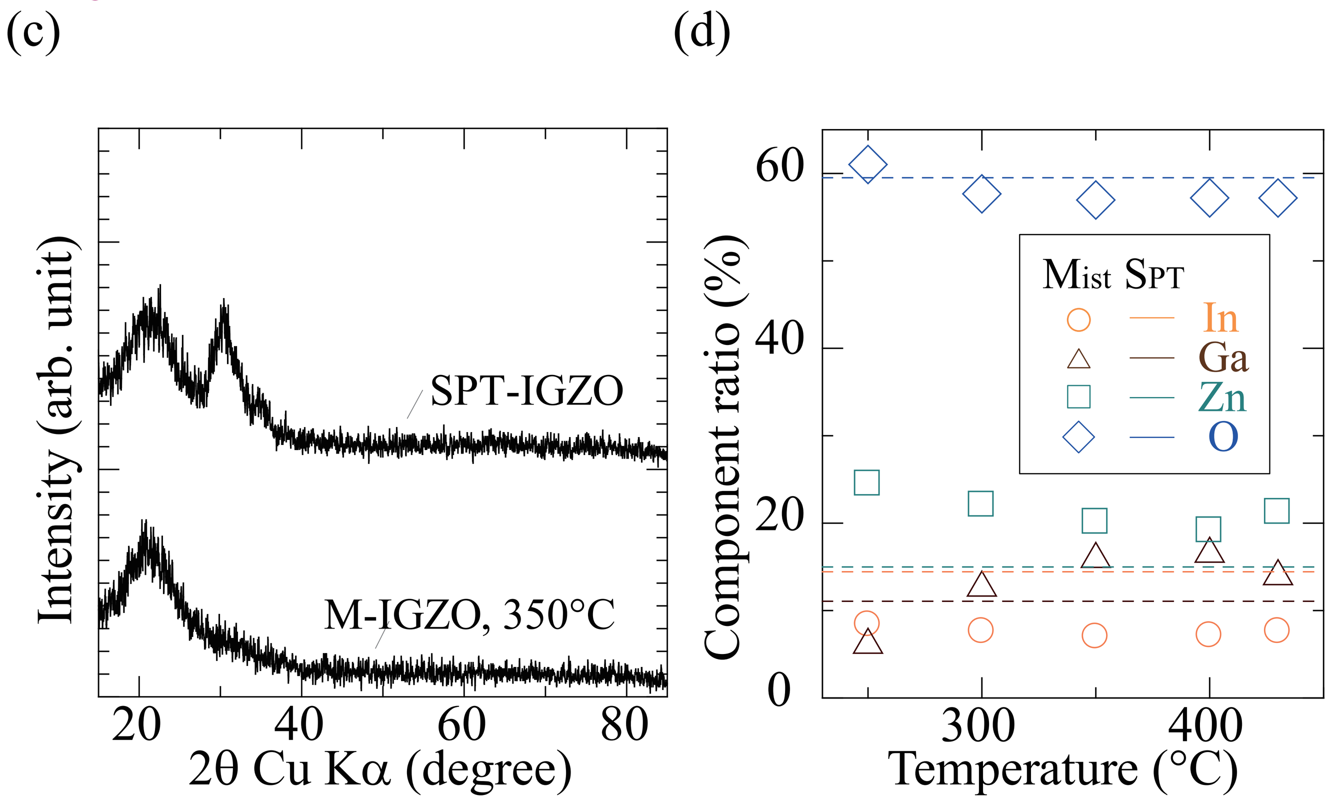
Solute	Aluminum acetylacetonate ($AlAcac_3$)
Solvent (mixing ratio)	Distillated water, Methanol (10 : 90)
Solution concentration	0.020 mol/L
Thickness	≈ 50 nm, 200 nm
Substrate temperature	300, 350, 400, 430 °C
Substrate	p+-Si
Growth system	φ100 mm ver. FC type mist CVD system
Carrier gas / flow rate	Air, 2.5 L/min × 2
Dilution gas / flow rate	Air, 10.0 L/min × 2
Ultrasonic transducer	2.4 MHz, 24 V・0.625 A, 6

Table 2. Deposition conditions of IGZO thin films

Solute1	Indium acetylacetonate ($InAcac_3$)
Solute2	Gallium acetylacetonate ($GaAcac_3$)
Solute3	Zinc acetylacetonate ($ZnAcac_2$)
Solvent	Distillated water, Methanol (10 : 90)
Solution concentration	0.030 (1:1:1) mol/L
Thickness	≈ 200 nm
Substrate temperature	150, 200, 250, 300, 350, 400, 430 °C
Substrate	Quartz, Eagle XG
Growth system	φ100 mm ver. FC type mist CVD system
Carrier gas / flow rate	Air, 2.5 L/min × 2
Dilution gas / flow rate	Air, 10.0 L/min × 2
Ultrasonic transducer	2.4 MHz, 24 V・0.625 A, 6



(a) Breakdown field (E_{BD}), dielectric constant (k), and (b) Deposition rate of AlO_x thin films grown by mist CVD.

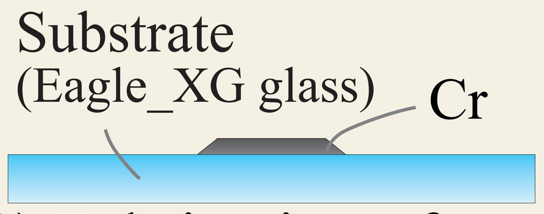


(c) XRD 2θ/ω spectra and (d) composition ratio of the IGZO thin films grown by the mist CVD

- Fabrication of Oxide TFT with an IGZO/AlO_x stack by mist CVD -

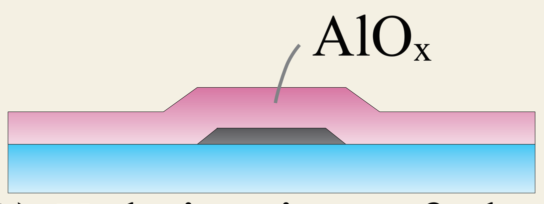
- Fabrication process -

(1) Fabrication of gate electrode



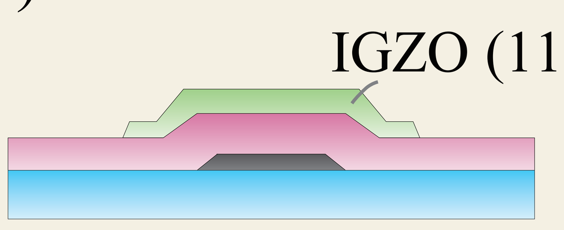
sputtering, 50 nm 150°C
Patterning: Wet etching

(2) Fabrication of gate insulator



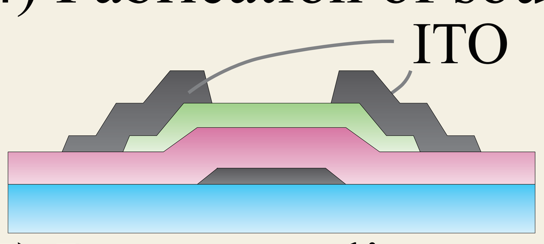
mist CVD (1 atm)
430°C, ≈ 100 nm
Patterning: Wet etching

(3) Fabrication of channel layer



mist CVD (1 atm)
350°C, ≈ 50 nm
Patterning: Wet etching

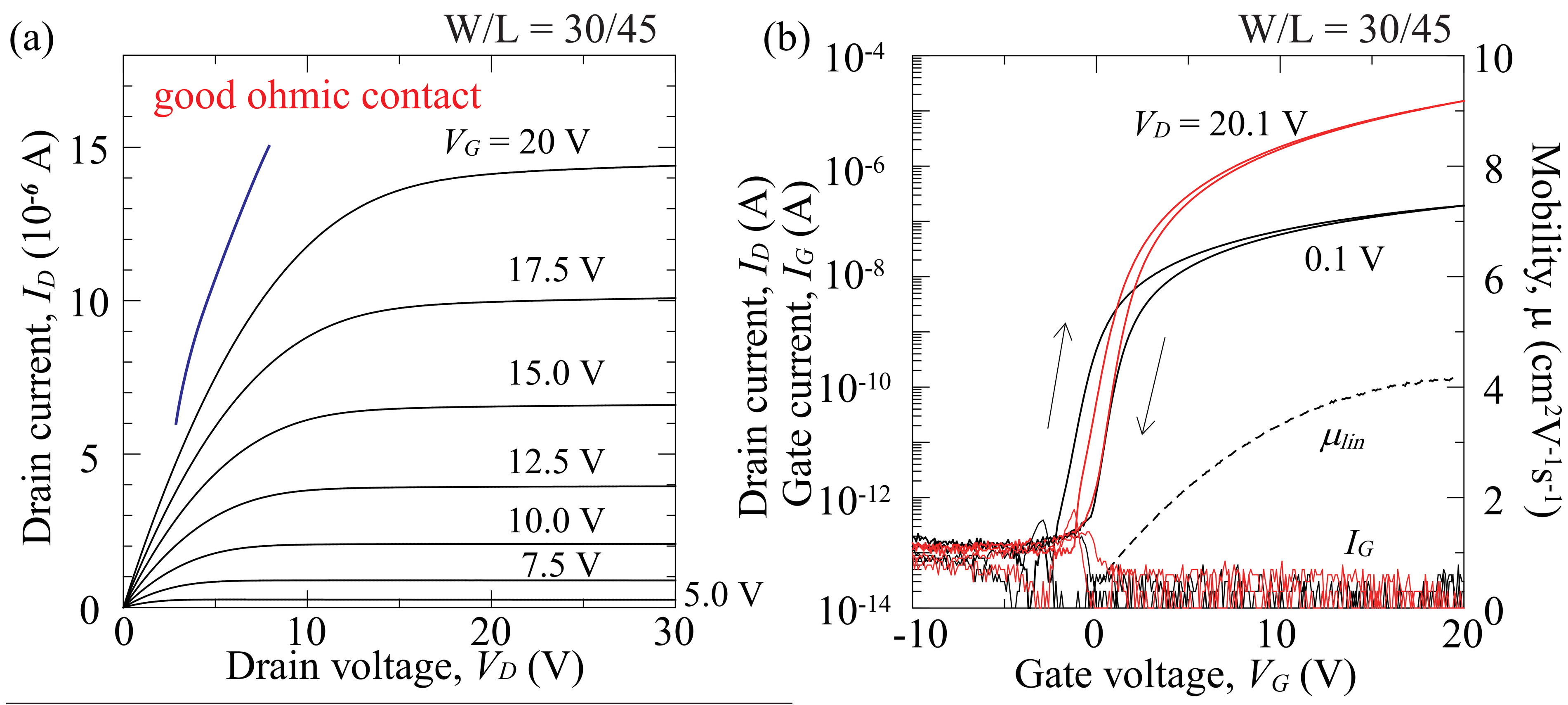
(4) Fabrication of source & drain electrode



sputtering, 50 nm, RT
Patterning: Wet etching
(lift-off)

(5) Post annealing H_2(3%) + N_2, 350°C, 1 h

- The drive of the first prototype -



Mobility μ ($cm^2V^{-1}s^{-1}$)	linear	:	4.2
	saturation	:	4.0
V_{GS} at I_{DS} = 1 nA (V)		:	0.39
S (V/dec.) @ 10-100 pA		:	0.55
Hysteresis ΔV_H (V)		:	0.68
I_{on}/I_{off} at V_{GS} = 30/-10 V		:	> 10^8
Gate leakage current @ V_G = 20V		:	<10^{-12}

The oxide TFT was driven with low leakage current & good on/off ratio.

S & ΔV_H are worse than previous reports

(a) Output and (b) transfer characteristics of oxide TFT with a IGZO/AlOx stack fabricated by mist CVD.

Conclusion

1) Oxide TFT consisting of both channel layer (IGZO) and gate insulator (AlO_x) grown by mist CVD which is one of suitable techniques for growing thin films continuously under atmosphere was fabricated.

2) The index of non-vacuum process conversion of the TFT fabrication process was demonstrated with fabricating the oxide TFT with an IGZO/AlO_x stack grown by the mist CVD.