P.147

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

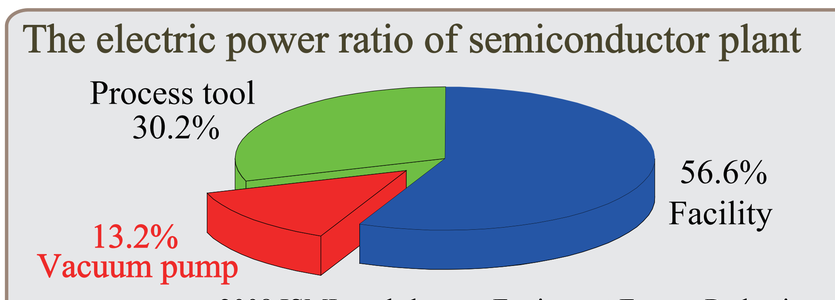
Toshiyuki Kawaharamura, Dapeng Wang, Mamoru Furuta

Institute for Nanotechnology, Kochi University of Technology

高知工科大学 KOCHI UNIVERSITY OF TECHNOLOGY

– 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.

Therefore, the conversion of TFT fabrication process to a non-vacuum process is attempted for environmentally friendly. The IGZO or IZO TFTs fabricated by spin coating method or sol-gel method have been reported in Ref. 1-4.

Source materials	Insulator	Channel layer	Post annealed	TFT properties	Ref.
$ZnAc_2$, $In(NO_3)_3$, (0.2:0.2 mol), 2ME	SiN_x, 400 nm, (PECVD), 150°C	IZO, 15 nm	300°C(5 min) 450°C(3 h), Air	μ = 6.57, on/off = 10^9, V_{on} = -1.5, V_{off} = -0.3, S = 0.15	[1]
$ZnAc_2$, $In(NO_3)_3$, $Ga(NO_3)_3$, ETA in 2ME	ATO, 220 nm, (ALD), ?°C	IGZO (In:Ga:Zn), 2:1:1-3, ≈ 25 nm	(80°C(5 min)+ 400°C(10 min), Air)×2, 400°C(1 h), Air	In:Ga:Zn = 3:1:1, μ = 5.8, on/off = 10^7, V_t = 8.1, S = 0.28	[2]
$ZnAc_2$, $SnCl_2$, $ZrCl_4$, 2ME	Th-SiO_2, (SiO_2/p^+-Si sub.)	ZrSnZnO (Zr:Sn:Zn), 0-1:7:4, ? nm,	500°C(2 h)	Zr:Sn:Zn = 0.3:7:4, μ = 4.02, on/off = 3.6×10^6, V_t = 3.1, S = 0.94	[3]
$ZnAc_2$, $In(NO_3)_3$, $Ga(NO_3)_3$, EMA in 2ME (1:25)	SiN_x, (? nm)	IGZO (In:Ga:Zn), 1-5:1:2, 50 nm	400°C(3 h)	In:Ga:Zn = 5:1:2, μ = 1.25, on/off = 4×10^6, V_t = -5.09, S = 1.05	[4]

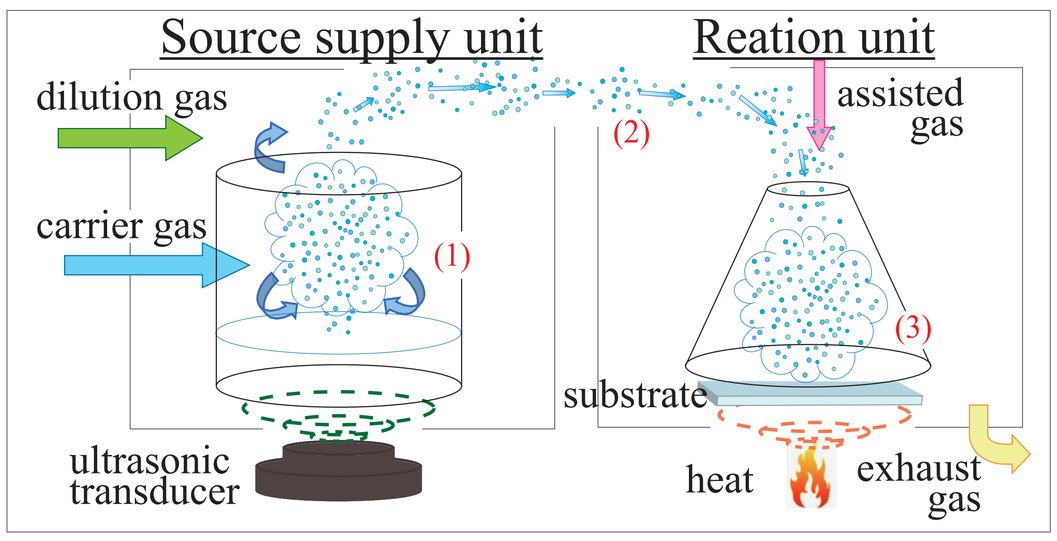
1) K-B. Park, et al., IEEE Electron Device Lett., Vol.31 (2010) pp.311.
2) P.K. Nayak, et al., Appl. Phys. Lett., Vol.97 (2010) pp.183504.
3) Y.S. Rim, et al., Appl. Phys. Lett.Vol.97 (2010) pp.233502.
4) G.H. Kim, et al., Appl. Phys. Lett., Vol.94 (2009) pp.233501.

However, in these reports, the gate insulator was prepared by vacuum process such as plasma-enhanced chemical vapour deposition (CVD). It is very important for the non-vacuum process conversion of TFT fabrication process to fabricate both a gate insulator and a semiconductor film by a non-vacuum 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 technique promising as an atmospheric pressure process!

Schematic view of mist method



Outlines of mist method

1) The source supply unit
The material solution is atomized to form mist droplets in the diameter scale of several micrometers with ultrasonic transducer.
2) The transportation unit
The mist droplets was transferred by carrier gas and dilution gas from the source supply unit to the reaction unit.
3) The reaction unit
The thin films or particles are formed by the thermal decomposition.

Producible films Metal oxide & organic films

Insulator : Al_2O_3, SiO
Semiconductor : ZnO, IGZO, Ga_2O_3, TiO_2
Conductor : AZO, GZO, ITO
Magnetic : Fe_2O_3

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
H																	He
Li	Be											B	C	N	O	F	Ne
Na	Mg											Al	Si	P	S	Cl	Ar
K	Ca	Sc	Ti	V	Cr	Mn	Fe	Co	Ni	Cu	Zn	Ga	Ge	As	Se	Br	Kr
Rb	Sr	Y	Zr	Nb	Mo	Tc	Ru	Rh	Pd	Ag	Cd	In	Sn	Sb	Te	I	Xe
Cs	Ba	lanth anoid	Hf	Ta	W	Re	Os	Ir	Pt	Au	Hg	Tl	Pb	Bi	Po	At	Rn
Fr	Ra	Actin oid	Rf	Db	Sg	Bh	Hs	Mt	Ds	Rg	Cn	Uut	Uuq	Uup	Uuh	Uus	Uuo

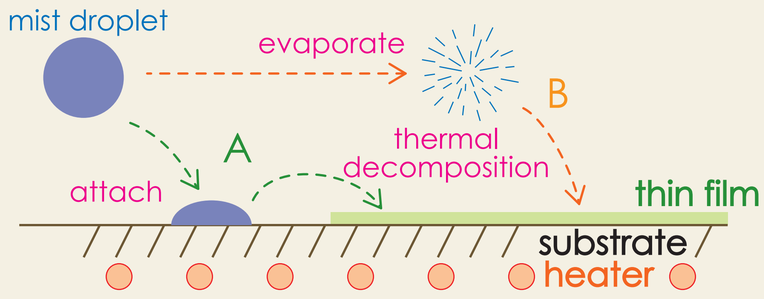
The metal oxide films which succeeded in growth
Nonmetallic element

Advantage of mist method

A. "Stable materials" can be treated 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.

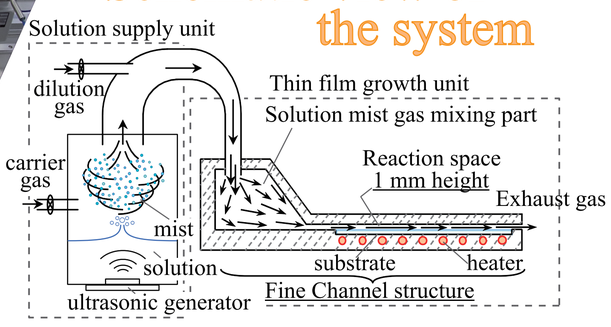


There is a big merit that stacked films can be continuously grown because the source solution does not directly attach to surface of the target film [5].

5) T. Kawaharamura, et al., Convertech, Vol.39 (2011) pp.111 [in Japanese].

Fine channel type Mist CVD system in our lab.

Schematic view of the system



Please refer **"Study on mist CVD and its application to the growth of ZnO thin films"**
T. Kawaharamura,, Ph.D. Thesis, Faculty of Engineering, Kyoto-Univ., 2008 [in Japanese]
http://repository.kulib.kyoto-u.ac.jp/dspace/bitstream/2433/57270/1/26041.pdf