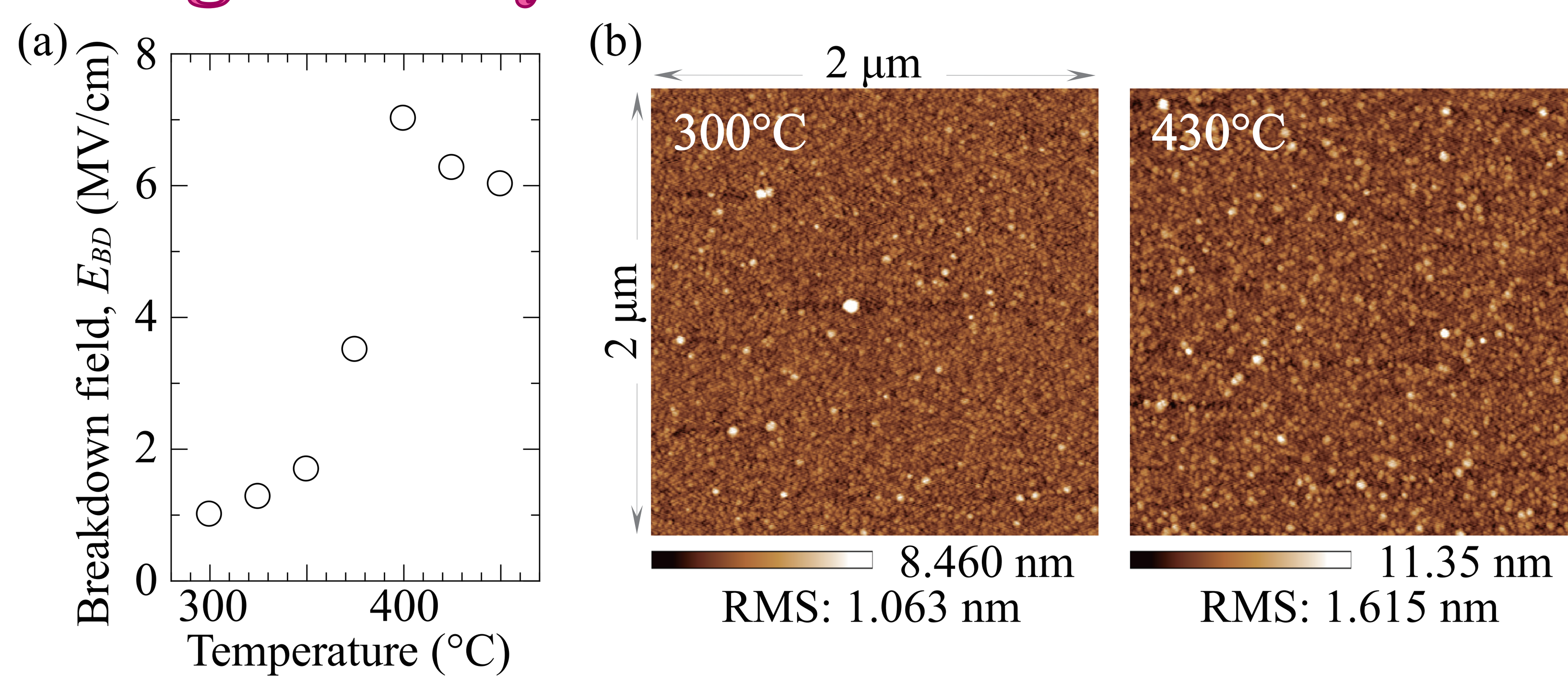
Properties of AlOx thin films grown by Mist CVD

Table 1. Deposition conditions of AlO_X thin films

Solute	Aluminum acetylacetonate ($AlAcac_3$)*2
Solvent (mixing ratio)	Distillated water*3, Methanol*4 (10 : 90)
Solution concentration	0.020 mol/L
Thickness	≈ 50 nm, 200 nm
Substrate temperature	300, 350, 400, 430 °C
Substrate	p+-Si*5
Growth system	φ100 mm ver. FC type mist CVD system*6
Carrier gas / flow rate	Air, 2.5 L/min × 2
Dilution gas / flow rate	Air, 10.0 L/min × 2
Ultrasonic transducer*1	2.4 MHz, 24 V·0.625 A, 6

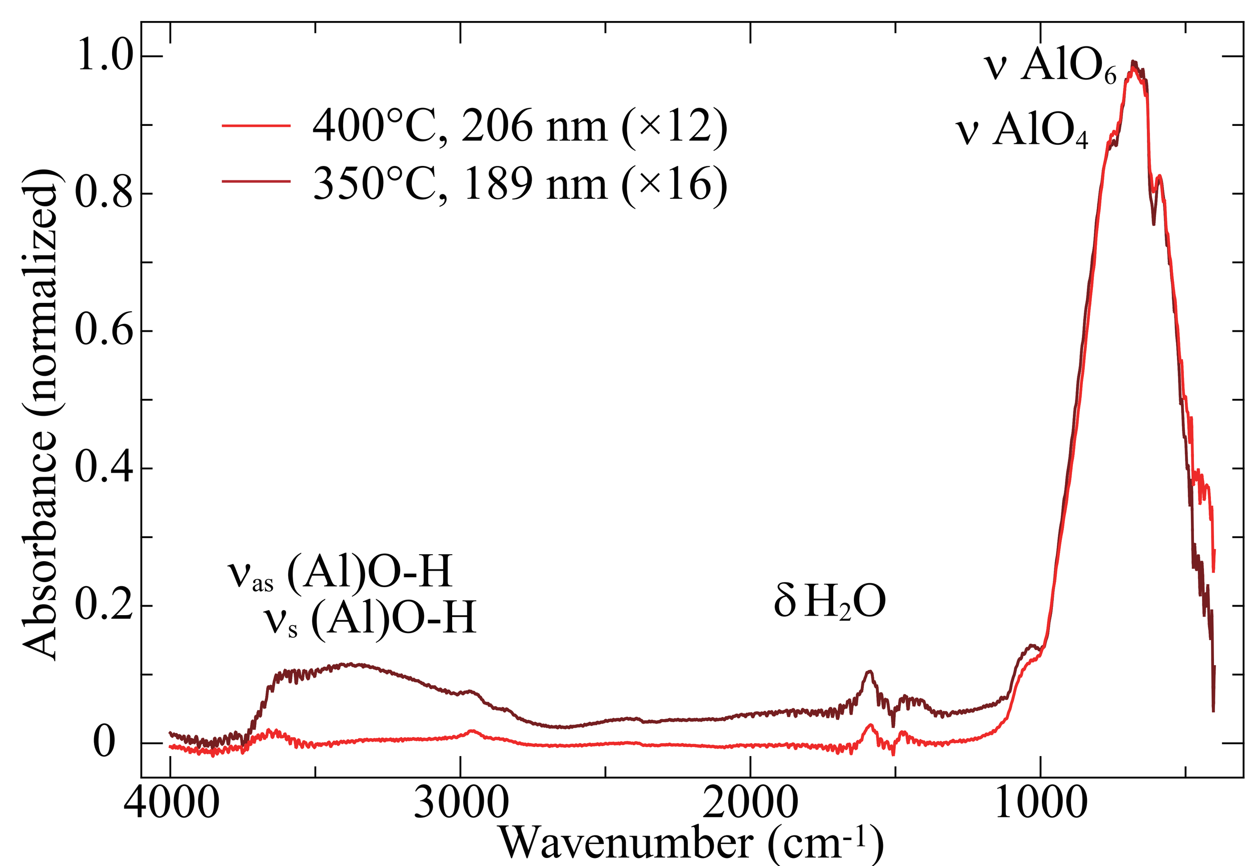
*1 HONDA ELECTRONICS, HM-2412
*2 Aluminum acetylacetonate, 99%, Sigma-Aldrich
*3 Wako Pure Chemical Industries
*4 Methanol, 99.8%, Wako Pure Chemical Industries
*5 Advantec
*6 Refs. 9 and 16.



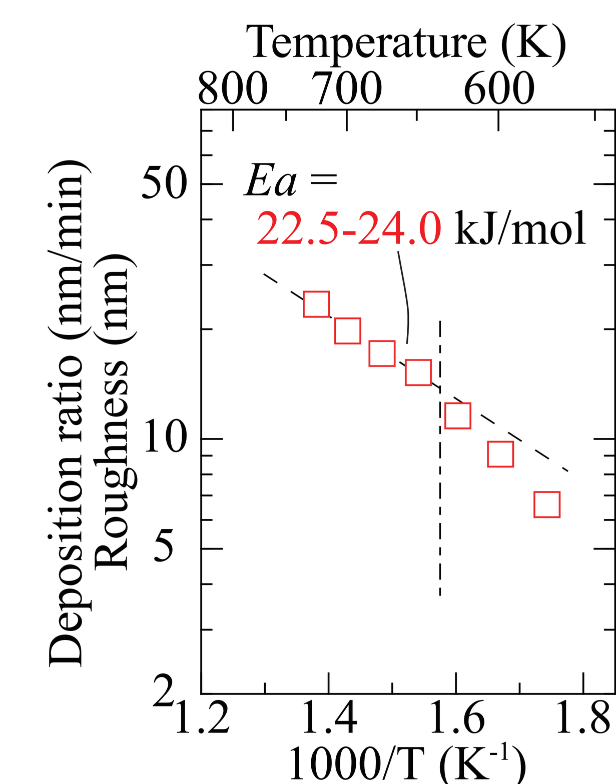
(a) Breakdown field (E_{BD}), and (b) surface structure of AlO_x thin films grown by mist CVD.

T > 400°C
E_{BD} > 6.0 MV/cm
k > 6.1
RMS =1.6 nm

The AlO_x thin films grown over 400°C exhibited the breakdown field and the dielectric constant of 6.0 MV/cm and 6.1, respectively. However, the E_{BD} of AlO_x thin film grown at temperatures below 350°C was dramatically declined.



FT-IR spectra of 200 nm thick AlO_x thin films grown by mist CVD.



Deposition rate and surface roughness of AlO_x thin films grown by mist CVD.

Compared with the AlO_x thin films deposited at various temperature, the difference of the shoulder around 1100 cm^{-1} corresponding to the bending vibration of Al-O-H ($ν_s$ (Al)O-H or $ν_{as}$ (Al)O-H) and the difference of peak around 2350 cm^{-1} corresponding to the stretching vibration of CO_2 adsorbed can be seen.

The logarithm of deposition ratio and surface roughness are not directly proportion to the reciprocal of the substrate temperature. The line has changed around 350°C.

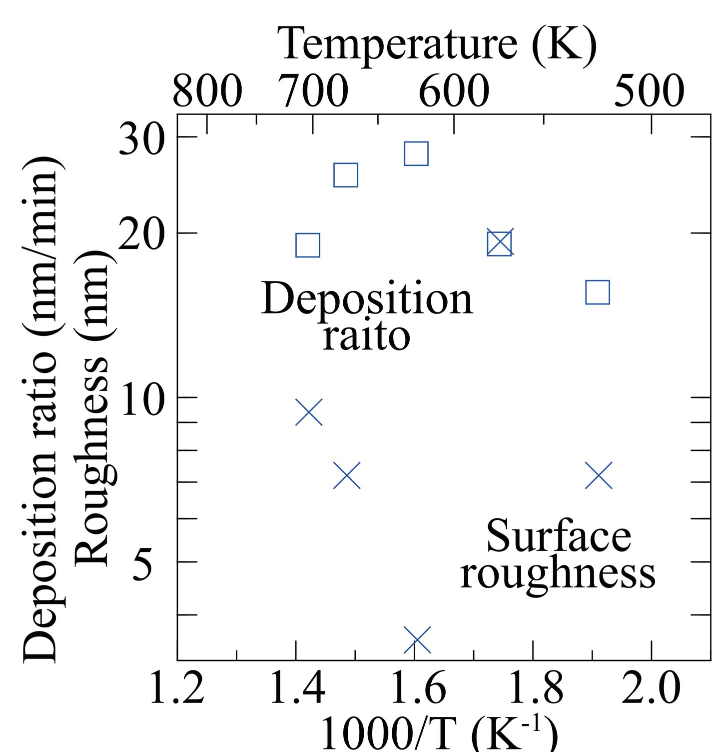
It is suggested that a residual as boehmite (γ-AlO(OH)) remains in the AlO_x thin film grown at the temperature below 350°C. It is thought that that is one of the reasons why the E_{BD} dramatically declines.

Properties of IGZO thin films grown by Mist CVD

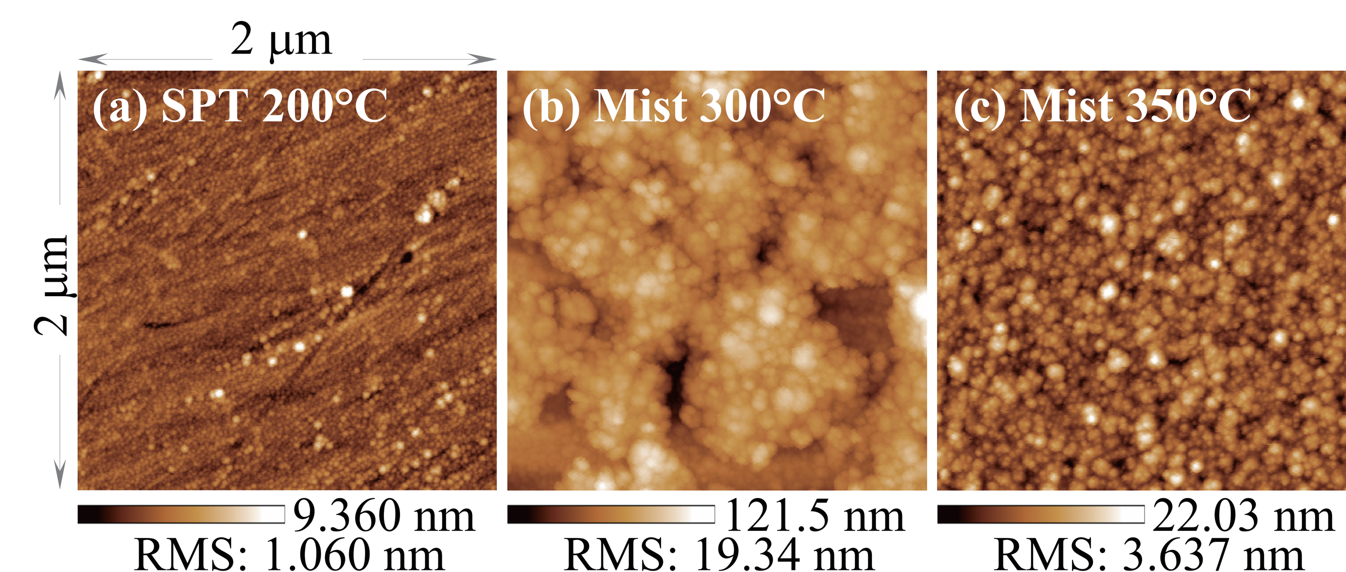
Table 2. Deposition conditions of IGZO thin films

Solute1	Indium acetylacetonate ($InAcac_3$)*2
Solute2	Gallium acetylacetonate ($GaAcac_3$)*3
Solute3	Zinc acetylacetonate ($ZnAcac_2$)*4
Solvent	Distillated water*5, Methanol*6 (mixing ratio: 10 : 90)
Solution concentration	0.030 (1:1:1)*7 mol/L
Thickness	≈ 200 nm
Substrate temperature	150, 200, 250, 300, 350, 400, 430 °C
Substrate	Quartz*8, Eagle XG*9
Growth system	φ100 mm ver. FC type mist CVD system*10
Carrier gas / flow rate	Air, 2.5 L/min × 2
Dilution gas / flow rate	Air, 10.0 L/min × 2
Ultrasonic transducer*1	2.4 MHz, 24 V·0.625 A, 6

*1 HONDA ELECTRONICS, HM-2412
*2 Indium(III) acetylacetonate, 99.99%, Sigma-Aldrich
*3 Gallium(III) acetylacetonate, 99.99%, Sigma-Aldrich
*4 Zinc acetylacetonate, >95%, nacalai tesque
*5 Wako Pure Chemical Industries
*6 Methanol, 99.8%, Wako Pure Chemical Industries
*7 In:Ga:Zn, atomic ratio
*8 Mitorika Glass
*9 Corning
*10 Refs. 9 and 16.



Deposition ratio and surface roughness of the IGZO thin films grown by the mist CVD



Surface structure of the IGZO thin films.

Surface of M-IGZO is rough compared with that of SPT-IGZO. Especially, in this case, Surface of M-IGZO is roughest at 300°C.

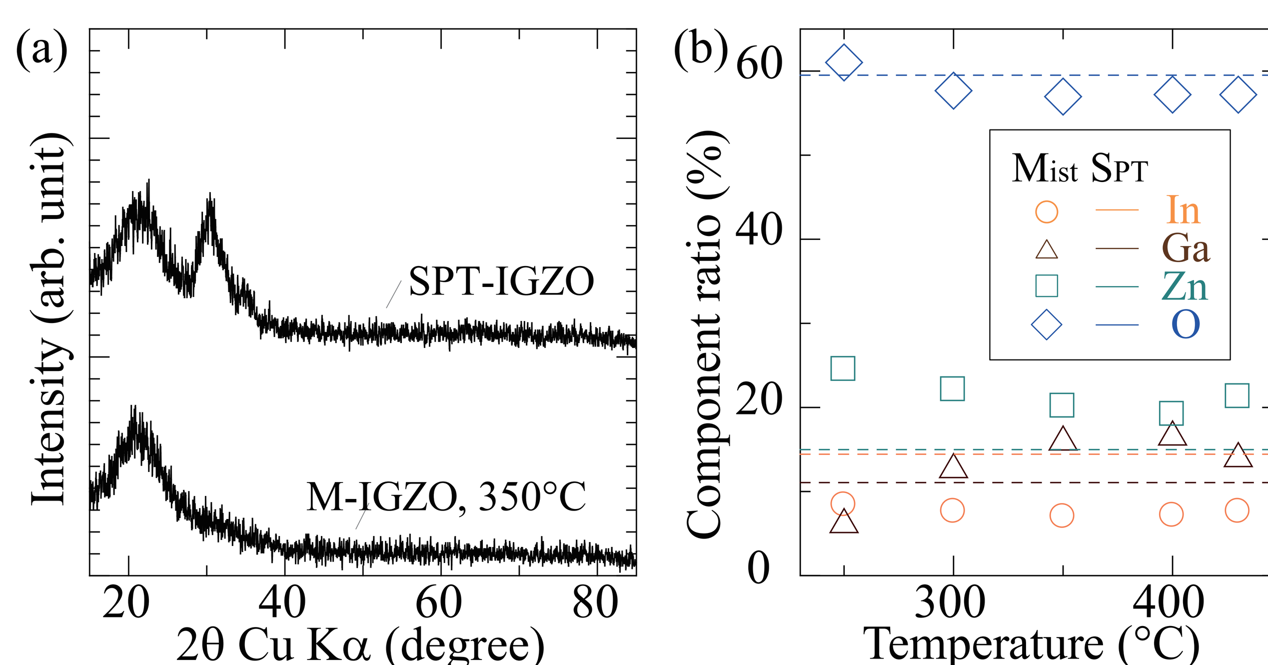
Deposition ratio of M-IGZO does not depend on temperature. This is because the dominant reaction shifts at each temperature domain due to each precursor with variant chemical reaction rate.

Both M-IGZO and SPT IGZO were amorphous since no diffraction peak was detected in XRD measurement.

From RBS measurement, the composition ratio of M-IGZO and SPT-IGZO were so different from ideal elemental ratio. In a SPT-IGZO, each metal composition ratio was 36:27:37 (In:Ga:Zn) owing to different sputtering ratio of each metal oxide contained in the target. In the mist CVD, composition ratio of films depends on growth temperature and mixture ratio of source materials at preparation. Hence, in a M-IGZO grown at 350°C, which is a same as the condition of IGZO thin film used for the channel layer of the oxide TFT, each metal composition ratio was 16:37:47 (In:Ga:Zn).

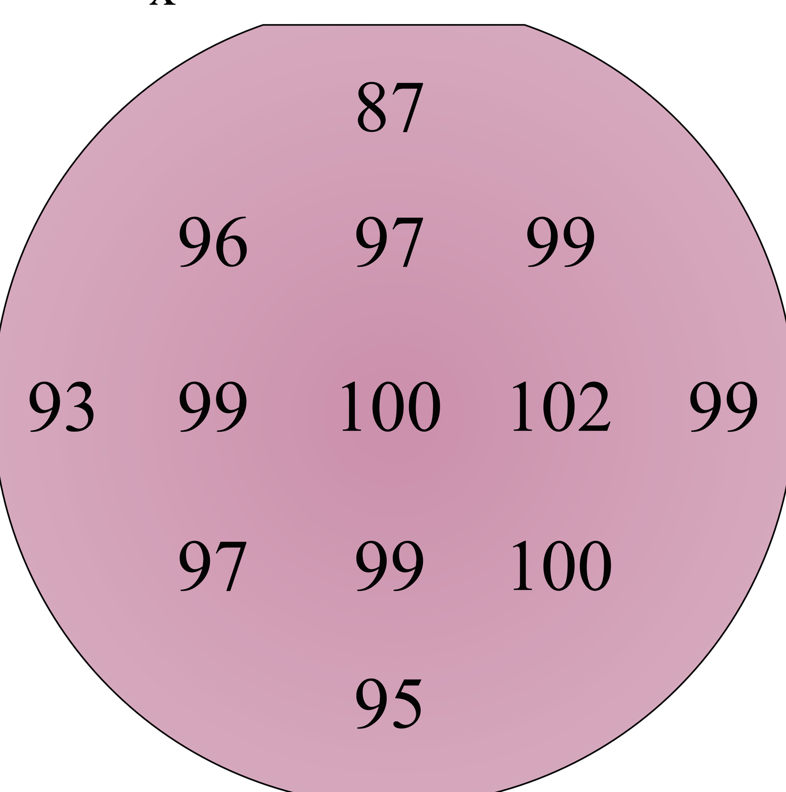
T =350°C
amorphous
depositon rate > 25 nm /min
In:Ga:Zn = 16:37:47

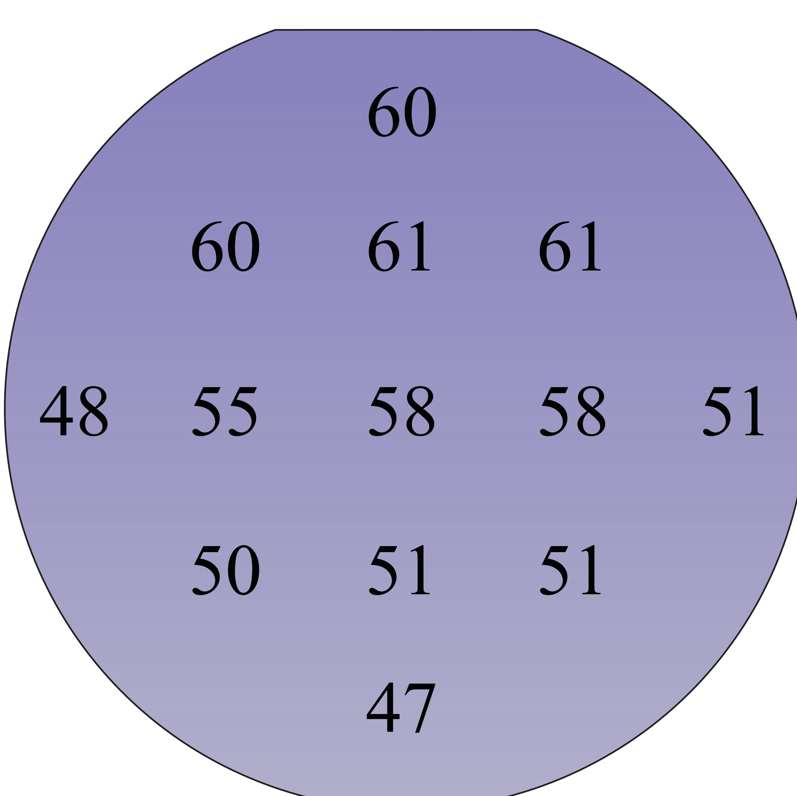
Change of dominant reaction depending on precursor is observed.



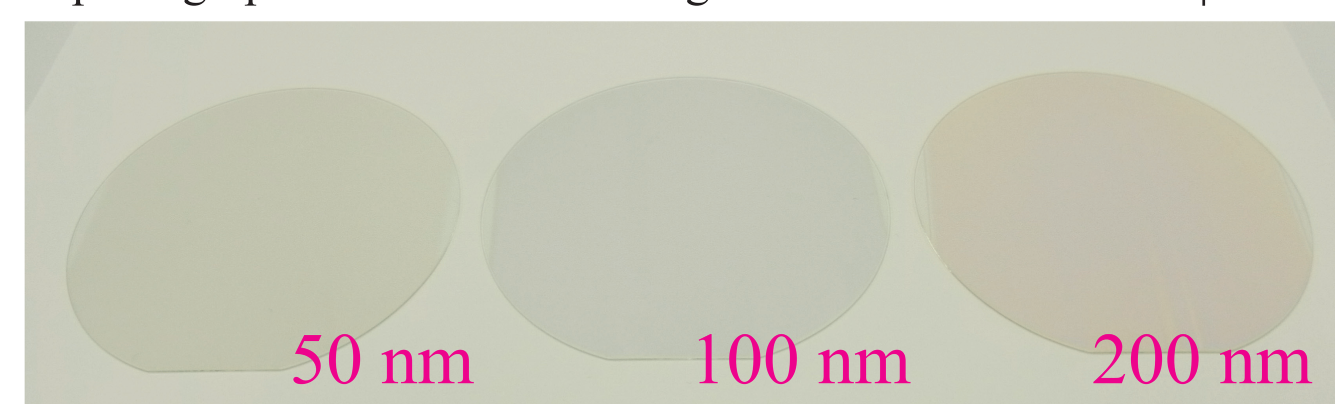
(a) XRD 2θ/ω spectra and (b) composition ratio of the IGZO thin films grown by the mist CVD

Uniformity of thin film grown by Mist CVD





The photograph of IGZO thin films grown on the substrate of ϕ100 mm.



AlO_x : Approximately-uniformity
IGZO : ±10%

In mist CVD, uniformity thin films can be get.