

Physical property, composition and structure of amorphous IGZO thin film

IGZO has attracted attention as a transparent electrode material such as display applications. Its electrical properties changed by the film deposition conditions, a difference in composition and internal structure of the thin film is affected. The change of the composition and structure in the amorphous IGZO film can be measured by Raman spectroscopy, RBS and XAFS.

Deposition Condition

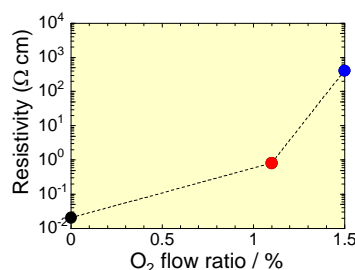
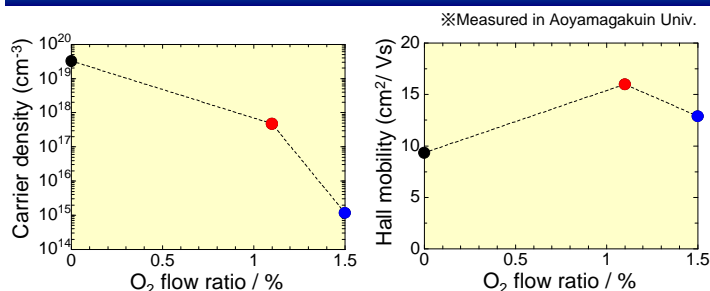
Method	DC magnetron sputtering
Target	InGaZnO ₄
O ₂ flow ratio O ₂ /(Ar+O ₂)	0%, 1.1%, 1.5%
Substrate	Si, glass
Thickness	about 300nm
Anneal	none

Composition

Rutherford backscattering spectrometry (RBS) can be determined nondestructively composition of the thin film, yet quantitatively without standard samples. Furthermore, using the nuclear reaction analysis (NRA), light elements such as oxygen also can be measured with high sensitivity.

O ₂ flow ratio	concentration(atomic%)				Ratio		
	In	Ga	Zn	O	Ga/In	Zn/In	O/In
0%	15.4	16.6	10.9	57.1	1.08	0.71	3.71
1.1%	16.0	15.9	10.4	57.7	0.99	0.65	3.61
1.5%	16.3	16.0	10.6	57.1	0.98	0.65	3.50
Target	14.3	14.3	14.3	57.1	1.00	1.00	4.00

Electrical property



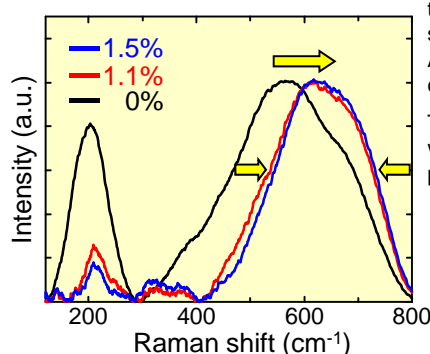
Increasing O₂ flow ratio, Carrier density is reduced.

Because the carrier density for 0% and 1.1% is approximately 10¹⁸ or more, the carrier is considered to be degenerate. On the other hand, it is considered that the conduction type is the percolation conduction for 1.5%.

Hole mobility is larger than 10 cm² / Vs, and it increases with increasing O₂ flow ratio. It takes a maximum value at around 1.1%.

Structure analysis

Raman spectroscopy (total reflection condition)



This method can be obtained information about the type of the elements and the crystal structure. Also in amorphous material can be applied.

The peak shifts to the high wave number side, and the peak width is narrow.

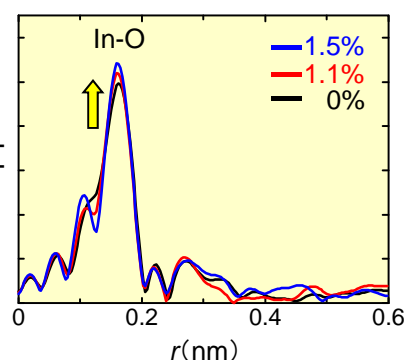
Improve the order of the amorphous structure

Radial Distribution Function around In by X-ray absorption fine structure(XAFS)

Information can be obtained relating to the distance and the existence probability of elements around a focus element.

Peak height of O atoms at the closest of In atoms increases.

Improve the order the arrangement for In atom around Oxygen atom



Correlation among the electrical property, composition and structure

By increasing the oxygen flow ratio during deposition,

- Change the composition
- Improving the order of the amorphous structure

Change in the oxygen vacancies and the electronic state

- Reduction of the carrier density
- Increase in the Hall mobility

Differences in the oxygen flow ratio during the film deposition is affect the film composition and the oxygen vacancies as a source of carrier electrons, also affects the order of the amorphous structure. Therefore it can be considered to result the overall change in the electrical characteristics.

※This study was collaborated with Prof. Shigesato at Aoyamagakuin Univ.