Indium iron tin oxide: a cheap solution for ITO?

Abstract

Indium tin oxide (ITO) is a solid solution of indium oxide (In$_2$O$_3$) and tin oxide (SnO$_2$). It is one of the most widely used transparent conducting oxides due to its excellent electrical and optical properties. The limited supply and high cost of indium however motivates the search for possible alternatives. One approach is to reduce the indium content by gradually substituting the In$_2$O$_3$ matrix with an isostructural oxide such as Fe$_2$O$_3$. In order to fast scan a wide range of different compositions, a technique is needed that offers both high flexibility as well as a good control over the film composition. This can be done using pressed powder targets in a DC magnetron setup, as the composition of the powder mixture can be easily varied[1].

1. Pressed powder targets are an easy alternative to quickly and efficiently scan a wide range of desired film compositions.
2. XRD measurements show that the Fe is indeed substituted into the In$_2$O$_3$ matrix, which results in a change of the preferential orientation of the film.
3. While the average transmission in the visible range increases with increasing Fe content, the same trend is noticed with the film resistivity. The resistivity at high Fe concentrations can be reduced by annealing, however, it still remains significantly higher than the resistivity of pure ITO. Hence it is doubtful that Fe would be a suitable candidate for the replacement of In in ITO applications.

Experimental setup

Sample composition

Deposition conditions:

Metallic depositions:
• fixed power 40W
• 0.8 Pa
• 10 sccm Ar

Reactive depositions:
• fixed 40W
• 0.3 Pa
• 10 sccm Ar / 3 sccm O$_2$
• poisoned mode

Correlation between target and sample composition:

\[
\text{metal ratio } i = \frac{C_i}{\sum C_j} \quad \text{with } C_i \text{ the at. } \% \text{ of } i = \text{In, Sn or Fe}
\]

XRD measurements

After deposition: amorphous films

Samples were annealed to 330°C at 5°/min.

Replacing In in In$_2$O$_3$ with Fe leads to:

1. Decrease in lattice parameter due to smaller atomic radius of Fe
2. Change in preferential orientation

Resistivity and transmission

Increasing the Fe content in the ITO film leads to:

1. Higher transmission
2. Increase in the film resistivity

Conclusions

1. Pressed powder targets are an easy alternative to quickly and efficiently scan a wide range of desired film compositions.
2. XRD measurements show that the Fe is indeed substituted into the In$_2$O$_3$ matrix, which results in a change of the preferential orientation of the film.
3. While the average transmission in the visible range increases with increasing Fe content, the same trend is noticed with the film resistivity. The resistivity at high Fe concentrations can be reduced by annealing, however, it still remains significantly higher than the resistivity of pure ITO. Hence it is doubtful that Fe would be a suitable candidate for the replacement of In in ITO applications.

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