Advanced Nano-technology
and
Applied Optoelectronics Lab

JOURNAL OF NON-CRYSTALLINE SOLIDS

# Performance comparison of hybird sputtering/evaporation $CuIn_{1-x}Ga_xSe_2$ solar cells with different transparent conducting oxide window layers

A.F da Cunha [a,*], F.Kurdeasu [a], D.Rudmann [b], P.M.P.Salome [a]

*Southern Taiwan University*

指導教授: 高至誠

學生　: 邱暐承

# Outline

- Introduction
- Experimental details
- Results and Discussion
  - SEM/EDX measurements
  - Transmission coefficients
  - I-V measurements
- Conclusion

# Introduction

- A possible approach is the adaptation of existing production equipment such as sputtering systems. The methods employed for Cu(In,Ga)$Se_2$ absorber layer deposition are coevaporation,rapid thermal processing (RTP) and $H_2Se$ selenization of Cu(Ga)/In metallic layers.
- For this purpose we have carried out a comparative study of the performance of solar cells with the usual i-ZnO/ZnO:Al and ITO window layers.

# Experimental details


i-ZnO/ZnO:Al or ITO

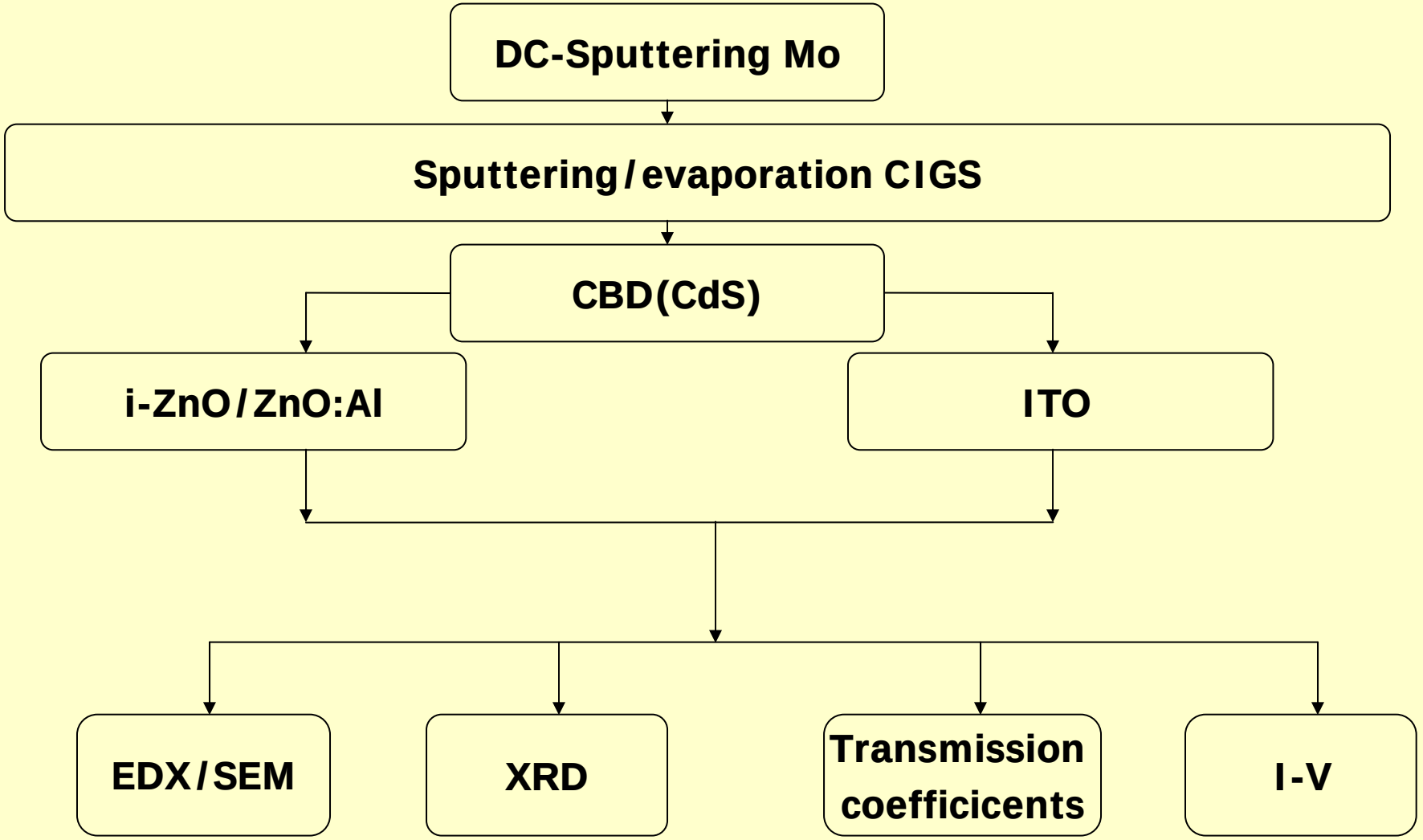
50nm (CBD)

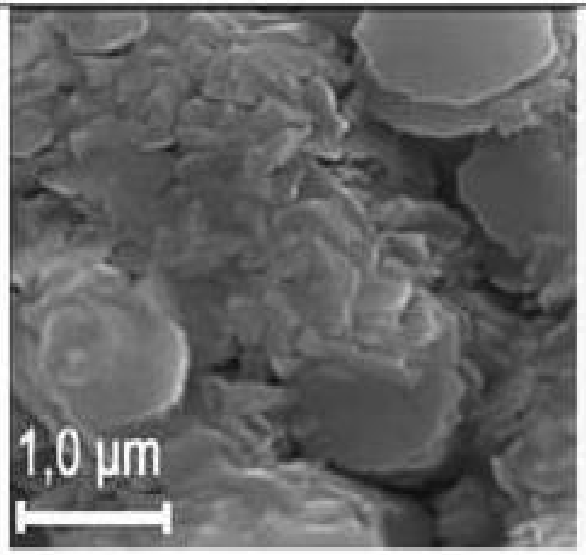
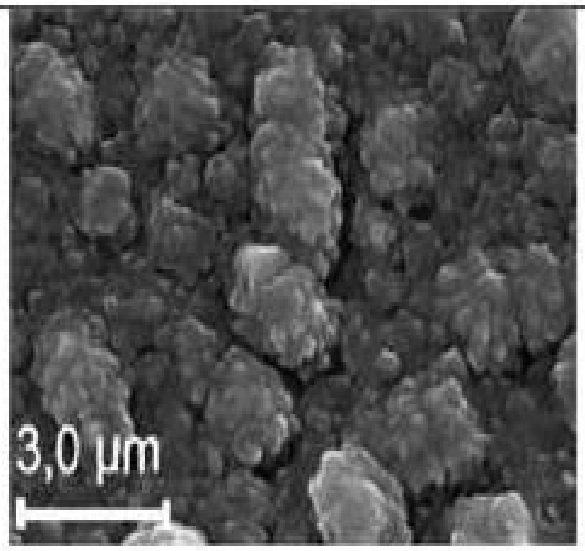
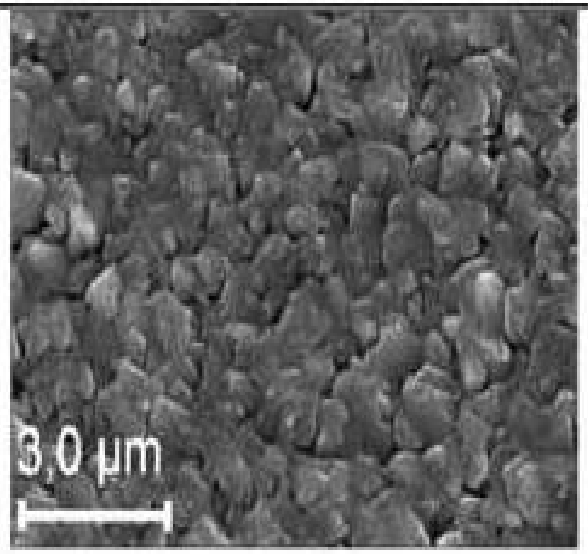
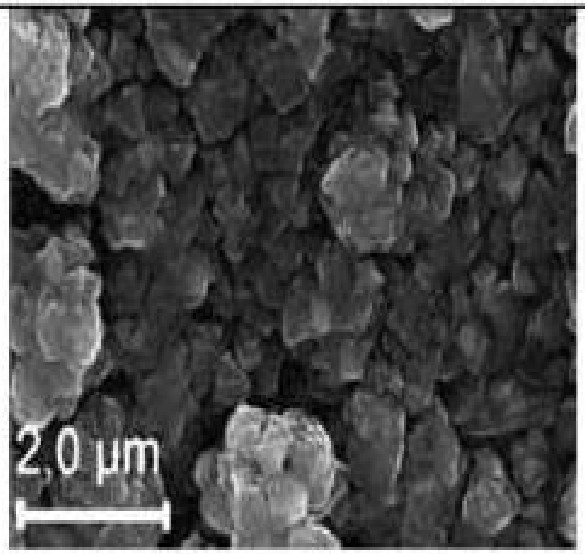
Sputter/evaporation

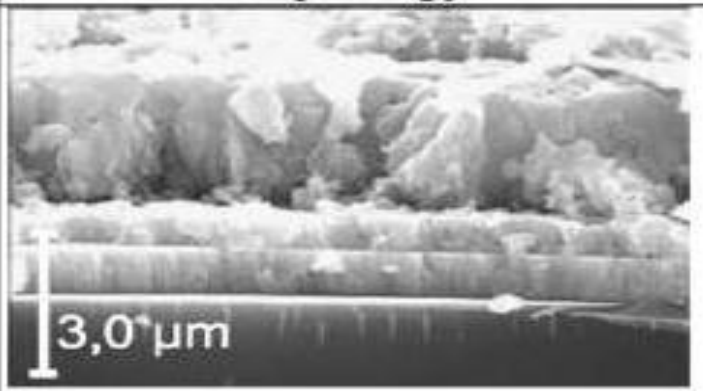
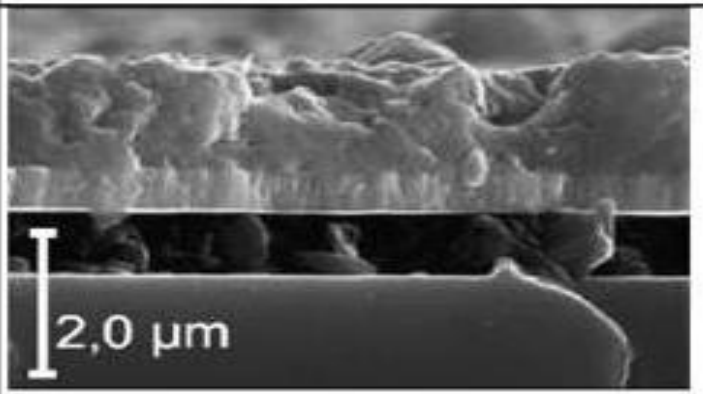
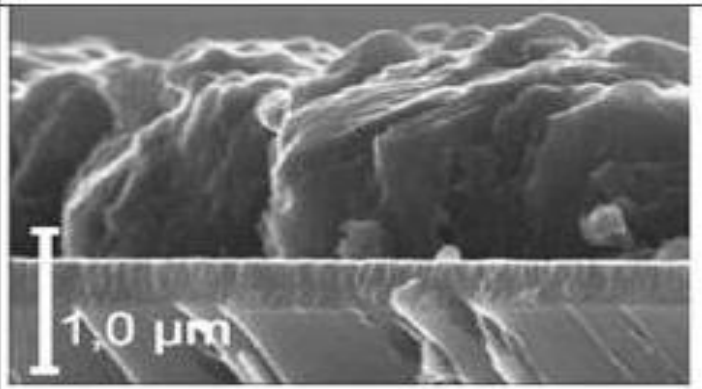
0.5 $\mu$ m(DC-Sputtering)

soda lime glass

# Experimental details



| Sample | Surface morphology | | |
|---|---|---|---|
| 1 |   | 3 |   |
| 2 |   | 4 |   |

| Sample | Cross-section morphology |
| --- | --- |
| 1 |   |
| 2 |   |
| 3 |   |

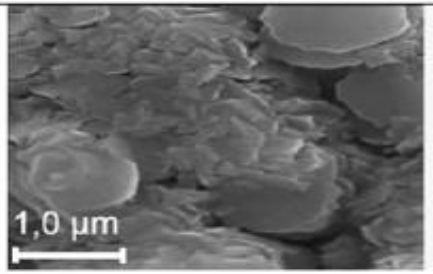
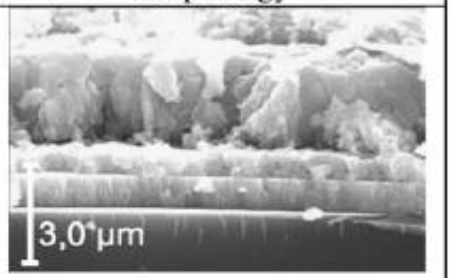
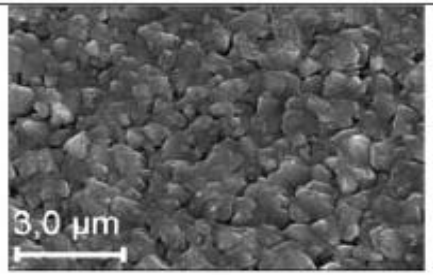
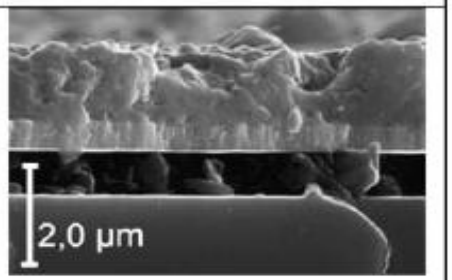
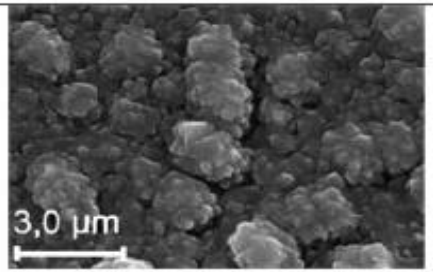
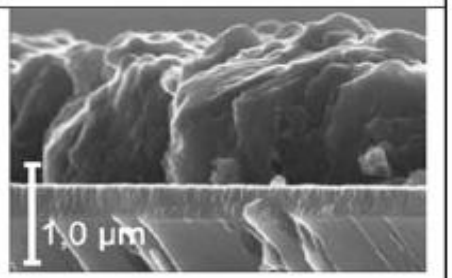
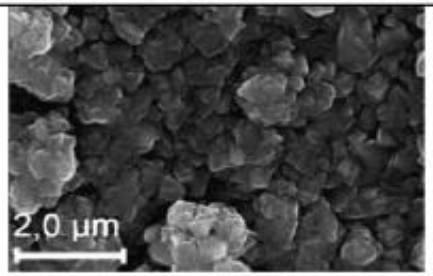
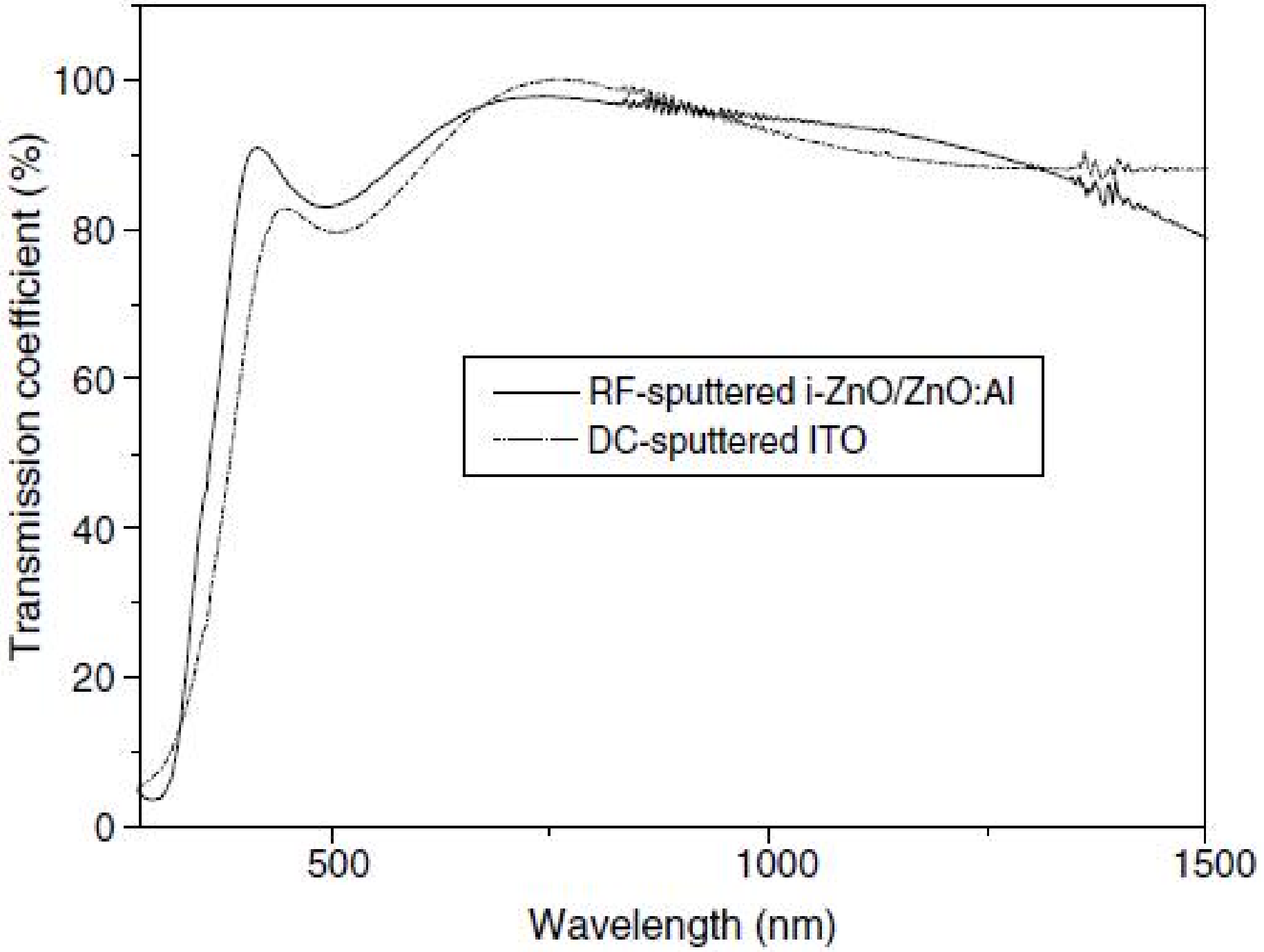
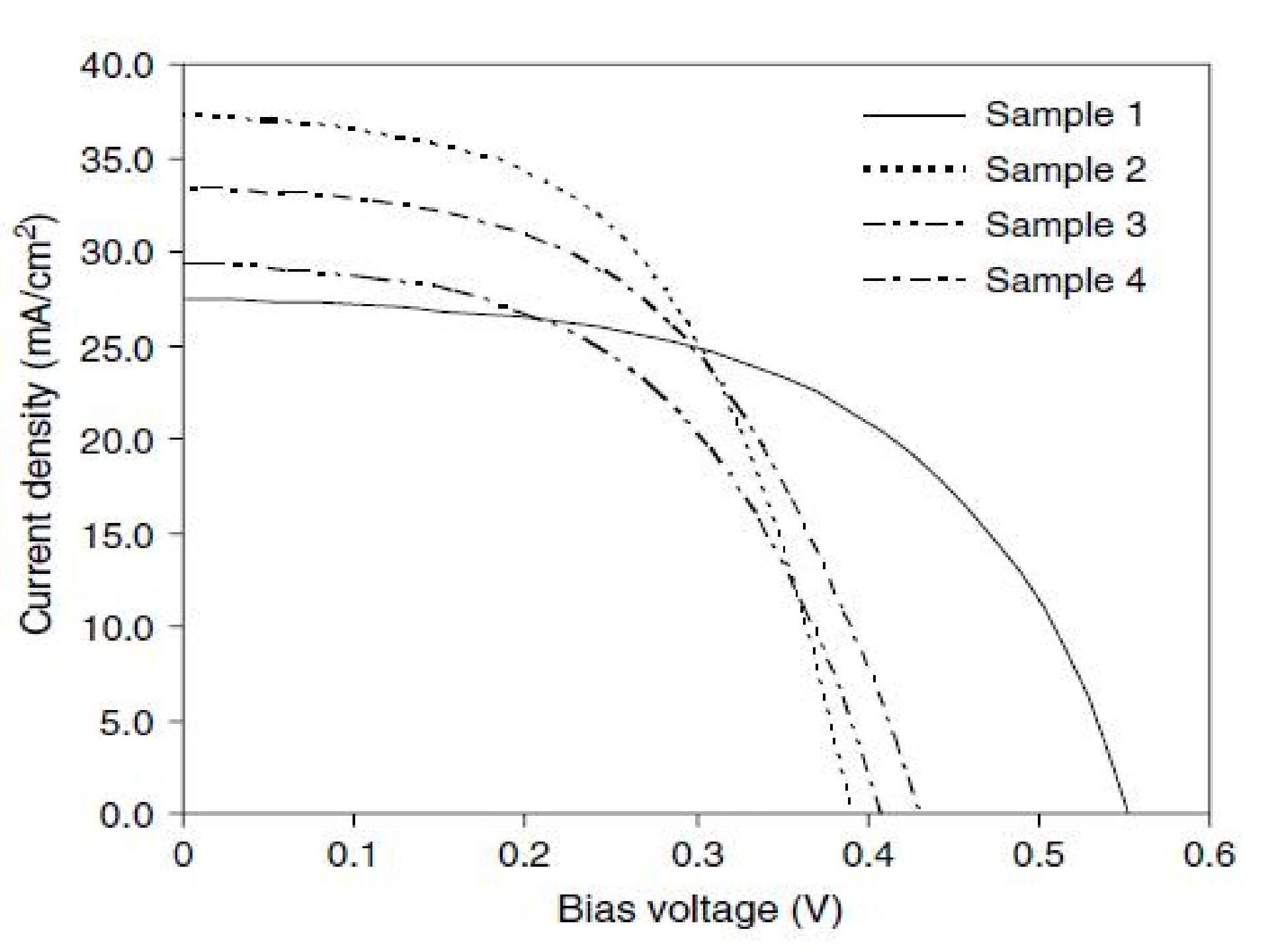
| Sample | Surface morphology | Cross-section morphology |
|---|---|---|
| 1 |   |   |
| 2 |   |   |
| 3 |   |   |
| 4 |   | |

Fig. 1. SEM surface (left) and cross-section (right) pictures of the CIGS solar cell absorber layers. The surface pictures show that the roughness of the CIGS absorbers vary from sample to sample for similar deposition conditions. The cross-section pictures show from top to bottom the CIGS layer, the Mo layer and the glass substrate.


Transmission coefficient (%)
100
80
60
40
20
0
500
1000
1500
Wavelength (nm)
RF-sputtered i-ZnO/ZnO:Al
DC-sputtered ITO


40.0
35.0
30.0
25.0
20.0
15.0
10.0
5.0
0.0
Current density (mA/cm2)
0
0.1
0.2
0.3
0.4
0.5
0.6
Bias voltage (V)
Sample 1
Sample 2
Sample 3
Sample 4

# Results and Discussion

| sample | ($cm^{-3}$) Absorber carrier density | Cell series resistance (Ω) | $V_{oc}$(mV) | $J_{sc}$($mA/cm^2$) | F.F.(%) | Cell efficiency (%) |
|---|---|---|---|---|---|---|
| 1 | $2.1\times10^{16}$ | 22.2 | 552.3 | 27.5 | 54.8 | 8.3 |
| 2 | $1.2\times10^{15}$ | 11.3 | 389 | 37 | 54.3 | 7.8 |
| 3 | $1.7\times10^{16}$ | 27.5 | 407.4 | 29.3 | 52.1 | 6.3 |
| 4 | $1.6\times10^{15}$ | 40.4 | 428.8 | 33.5 | 51.6 | 7.4 |

# Conclusion

- Solar cells have been prepared and studied with CIGS prepared by a two-stage sputtering/evaporation methodand finished with i-ZnO/ZnO:Al and ITO layers.
- The room temperature DC-magnetron sputtering of ITO has been optimized to obtain properties identical to the more commonly used

  i-ZnO/ZnO:Al window layer.

Thanks for your attention