Investigation of the CISSe thickness on solar cell performance

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Abstract

The flourishing copper-indium-sulfur-selenide (CISSe) thin film solar cell is based on the p-type CISSe.The main absorption layer, which is a direct bandgap with good power conversion efficiency, has a wide absorption wavelength range (300~1300 nm). If the absorber layer is too thick, the carriers will not able to be collected. On the contrary, if the absorber layer is too thin, the number of absorbed photons will be too less.

This studying about the CISSe with different absorption layer thickness has a suitable width of depletion region and high short-circuit current.We use raman spectroscopy, scanning electron microscope (SEM) and photo-excitation spectrometer (PL) to identify the structure, element composition and thickness of the absorber layer.Futhermore, we use solar simulator and measure the external quantum efficiency to obtain more details inside.

I. Motivation

Why CISSe ?

- ◆Wide absorption wavelength (300-1300 nm)
- ◆Commercialized thin film solar cell
- ◆High efficiency
- ◆Stable performance(Light, thin, flexible and temperature has a low impact on efficiency)
- ◆ Direct band gap (1.04~1.67 eV)

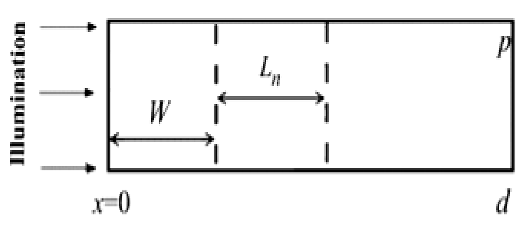
Why need to control the absorber thickness ?

◆The thicker absorber layer

⟶ need longer diffusion length

◆The thinner absorber layer

⟶ generate less carriers

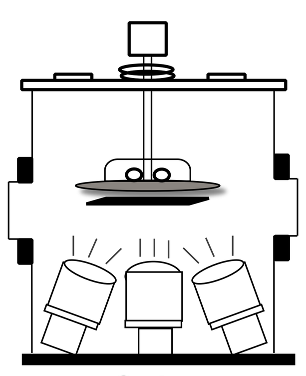


Why use the sputter?

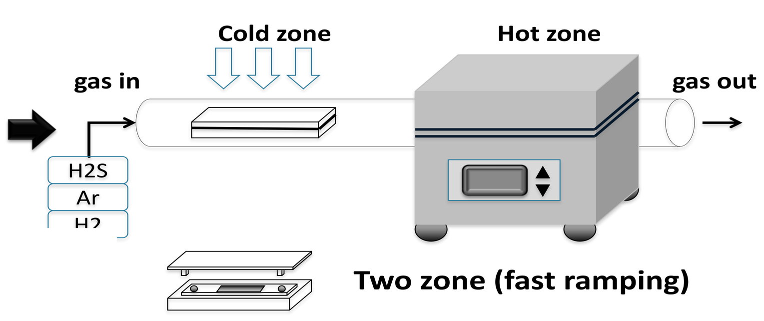
	Sputter	Non-vacuum
Process	Hard	Easy
Temperature	High	Low
Surface damage	Sputter damage	No
Quality	High	Low
Uniform	Uniform	Not sure
Control thickness	Easy	Easy
Cost	High	Low
Pollution	No	Yes

II. Experimental Method

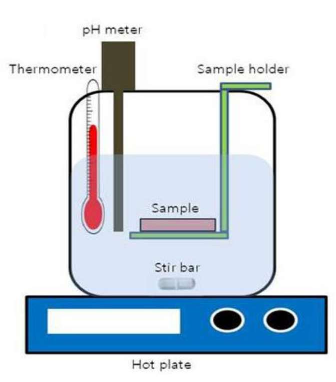
1. Cu-Zn-Sn metal precursor by sputter



2. Sulfo-selenization at 550°C

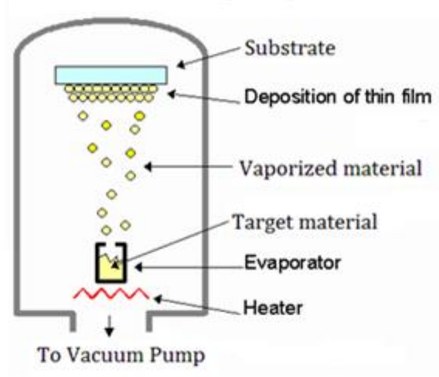


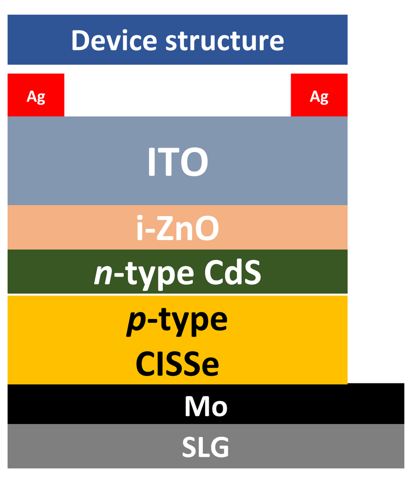
3. CdS buffer layer by CBD



4. i-ZnO and ITO window layer by sputter deposition

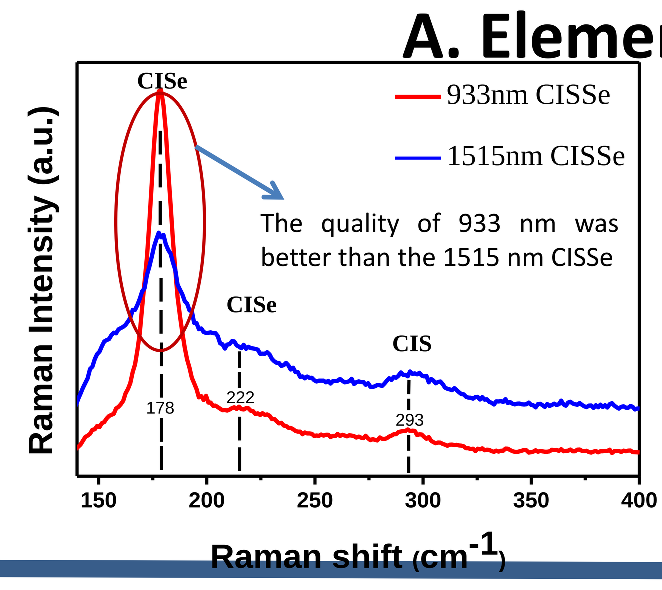
5. Ag metal finger by thermal evaporation

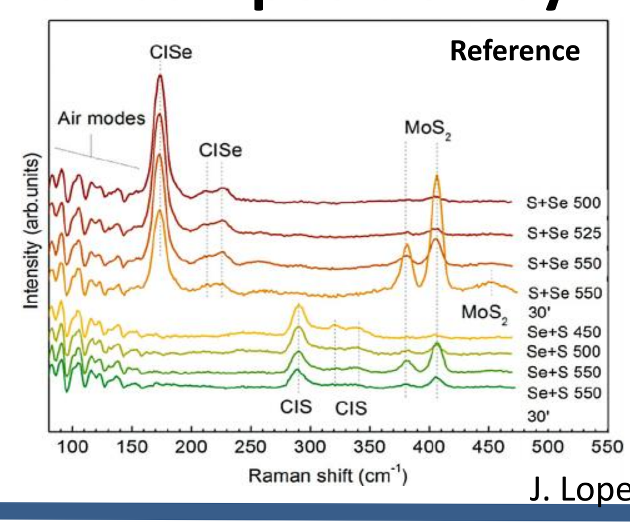




III. Result and discussion

A. Elemental Composition by Raman

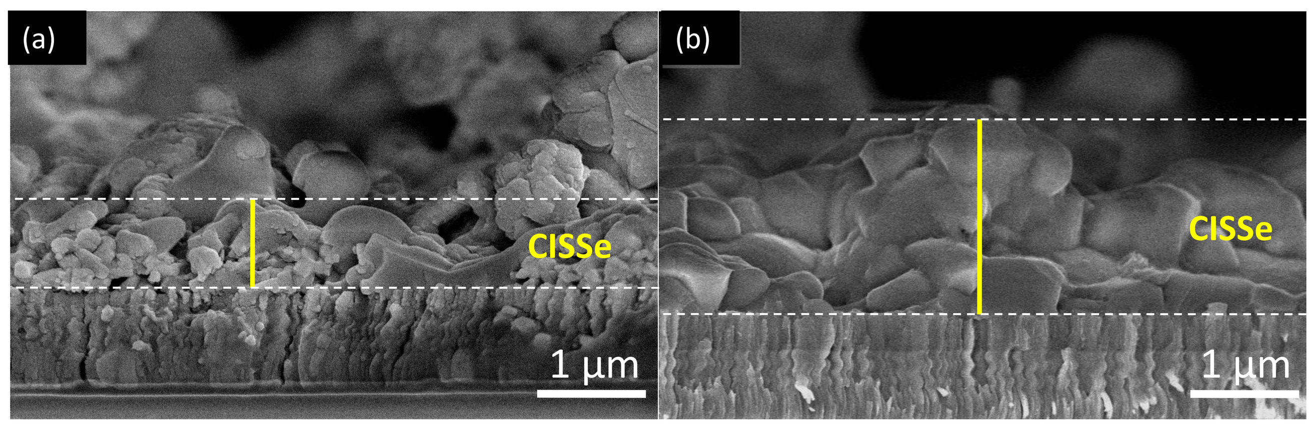




Raman data compared with the raman of the reference , successfully synthesized the CISSe single phase

J. Lopez-Garcia et.al. , *Materials Chemistry and Physics,* (2015)

B. Morphology Structure by cross-section SEM

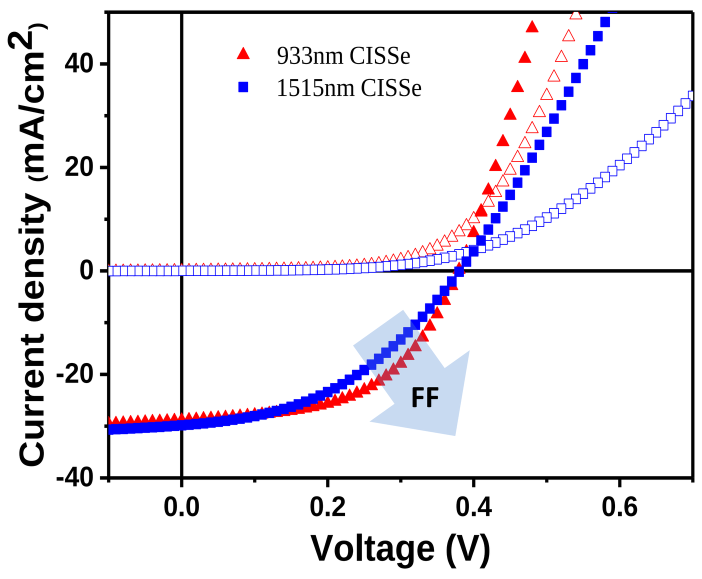


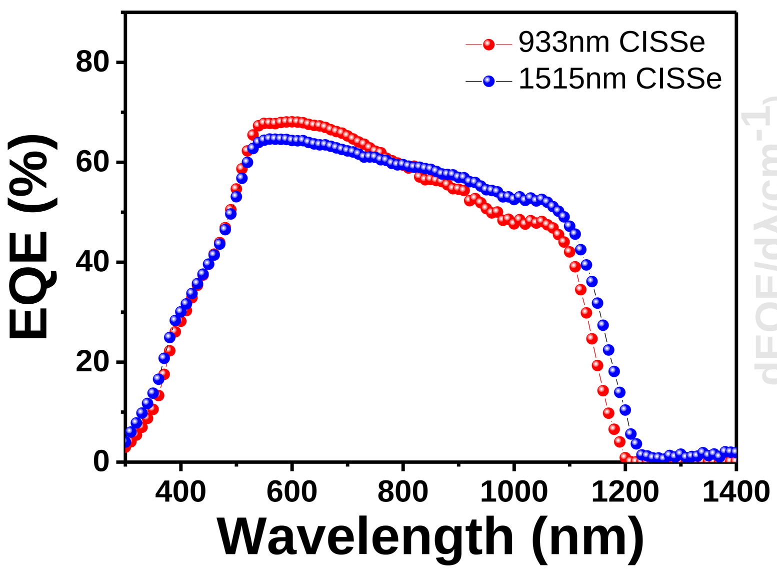
◆Cross-section SEM of CISSe absorber layer thickness

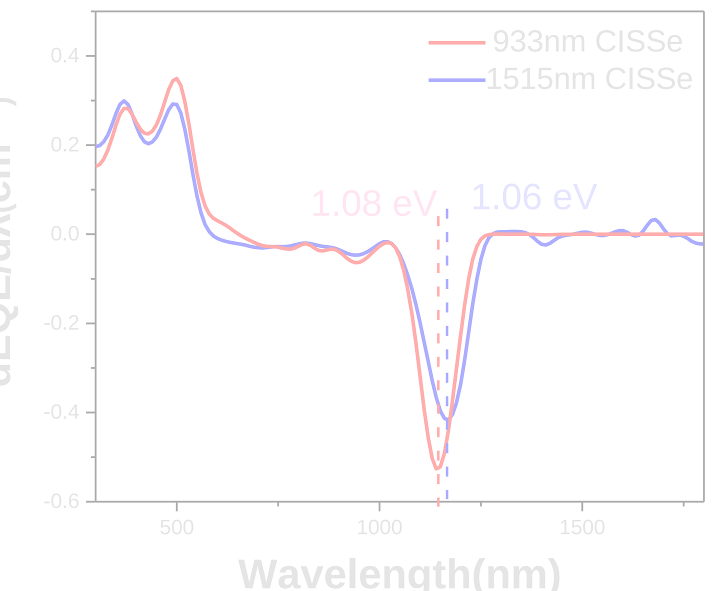
◆ (a) 933nm

◆ (b) 1515nm

C. PV Performance by I-V and External Quantum Efficiency Measurement







1. Because the quality of 933 nm CISSe was better than the 1515 nm , the cross over of 933nm CISSe was smaller
2. Especially the fill factor of 933nm CISSe was better than 1515 nm CISSe .

1. In the short wavelength, the quality of 933 nm was better, so it was higher than 1515 nm CISSe.
2. In the long wavelength, the thickness of 933 nm CISSe was not enough, so it was worse than 1515 nm CISSe.

1. The bandgap of 933 nm CISSe was 1.08 eV
2. The bandgap of 1515 nm CISSe was 1.06 eV

E. Resume of Device Performance

◆The performance of 933 nm CISSe was better than 1515 nm CISSe performance.

Device	V_{oc} (mV)	η (%)	FF (%)	J_{sc} (mA/cm^2)	R_s (Ω. cm²)	R_{sh} (Ω. cm²)
933nm CISSe	380±10	5.31±0.38	53.21±2.83	26.3±0.57	3.53±0.26	128.59±34.75
1515nm CISSe	380±10	4.11±12.86	42.65±0.89	25.31±0.17	5.53±1.66	83.26±122.47
Best cell (933nm CISSe)	401	5.9	58.33	26.86	2.95	192.59

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Reference

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