

# Combined Raman scattering, X-ray fluorescence and ellipsometry *in-situ* monitoring of CuInSe<sub>2</sub>-based photoabsorber layers on polyimide substrates



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http://www.uni-leipzig.de/ellipsometrie

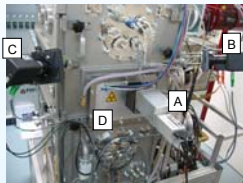
## Our Message

- First *in-situ* application of Raman scattering spectroscopy to industrial roll-coater deposition
- Combination with *in-situ* spectroscopic ellipsometry and *in-situ* X-ray fluorescence (XRF)
- Successful application to CIS based thin film solar cell absorber on flexible substrates

## Introduction

### Roll-coater

*In-situ* setup



- A: In situ Raman head
- B: In situ ellipsometer input unit
- C: In situ ellipsometer output unit
- D: In-situ XRF unit

### Raman head

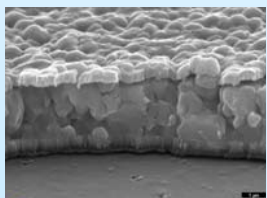
In-house built, high power, large aperture



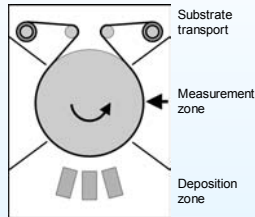
### Solar cell structure

SEM image

- CdS/ZnO/ITO front contact system
- CIS Absorber
- Mo back contact



Schematic drawing

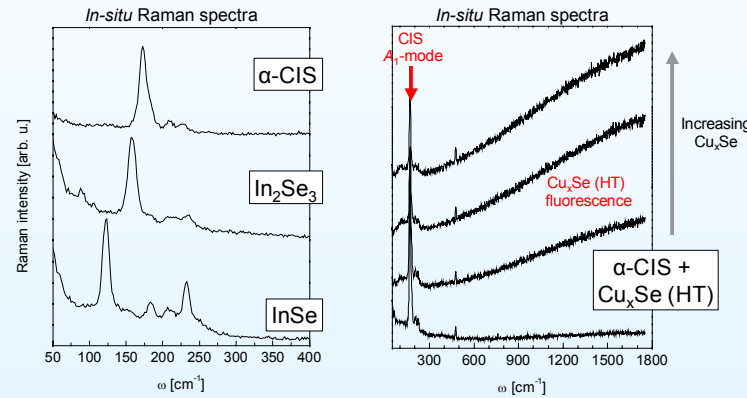


## In-situ Raman scattering

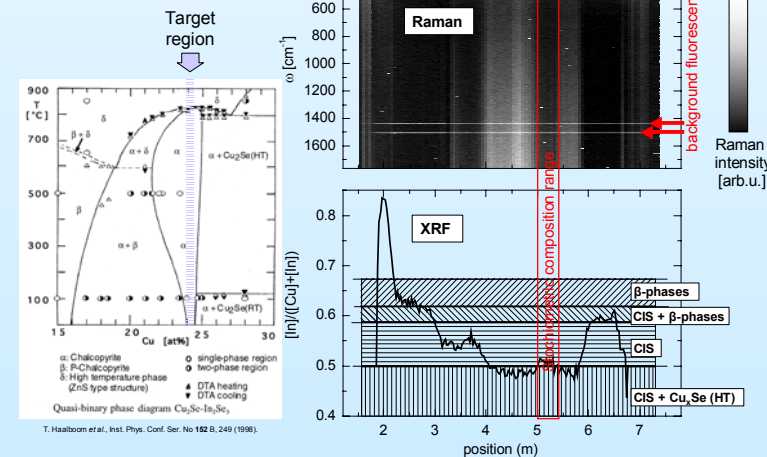
Raman scattering studies optical phonon modes (frequency, broadening)



Crystal phase  
Crystal quality



### CIS absorber layer



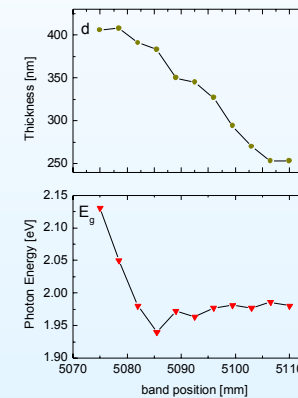
## In-situ spectroscopic ellipsometry

Spectroscopic ellipsometry



Dielectric function spectra (band gap energy, index of refraction)  
Thickness (growth rates)

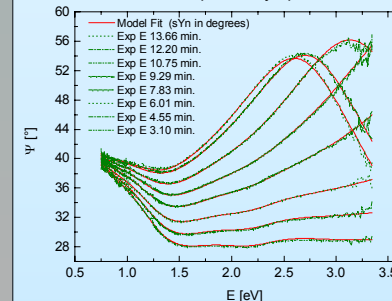
### In<sub>x</sub>Se<sub>y</sub> layers



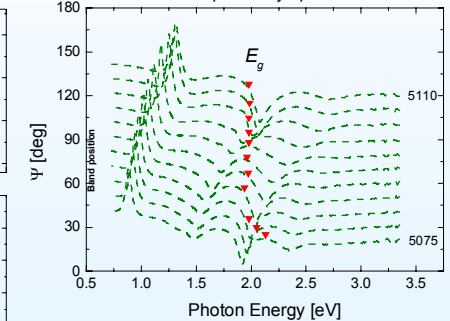
### Buffer layer

Used to improve electrical properties of the CIS absorber layer  
Crucial parameter is layer thickness

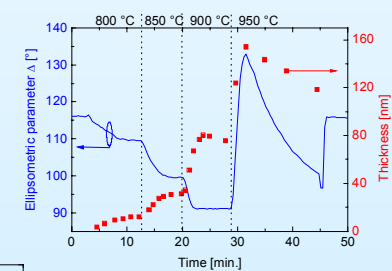
### In-situ ellipsometry spectra



### In-situ ellipsometry spectra



### Delta and thickness vs. time



### Optical constants

