Fabrication of CIGS films by using MBE for tandem solar cells

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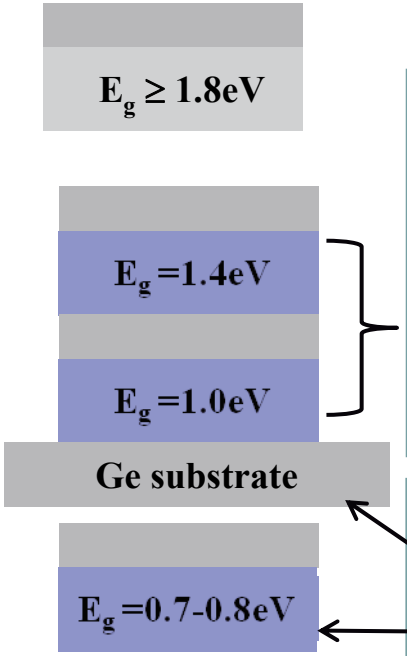
Objective:

development of high-efficiency compound semiconductor-based tandem solar cells

Efficiency goal at 2010:

development of technologies to demonstrate over 20%-efficiency tandem solar cells



CIGS-based tandem structures

Mechanical –stack
- improvement of conversion efficiencies of solar cells on TCO back contact
- bonding techniques

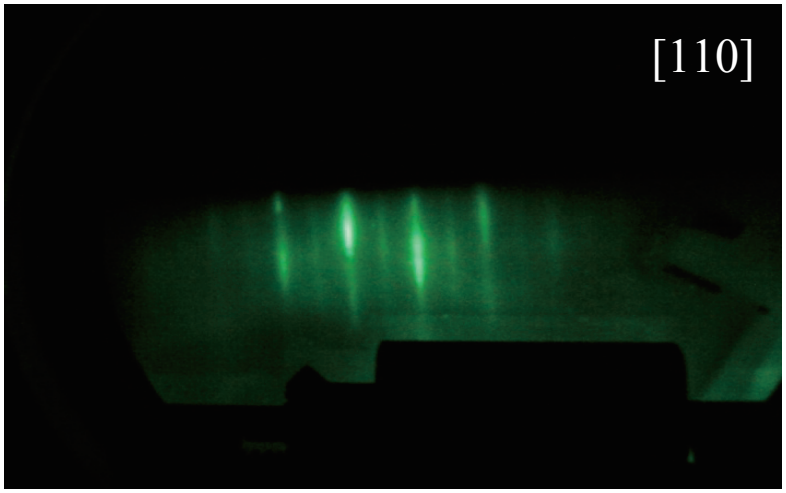
Monolithic
- low-temperature absorber deposition
- temperature-resistive buffer layer

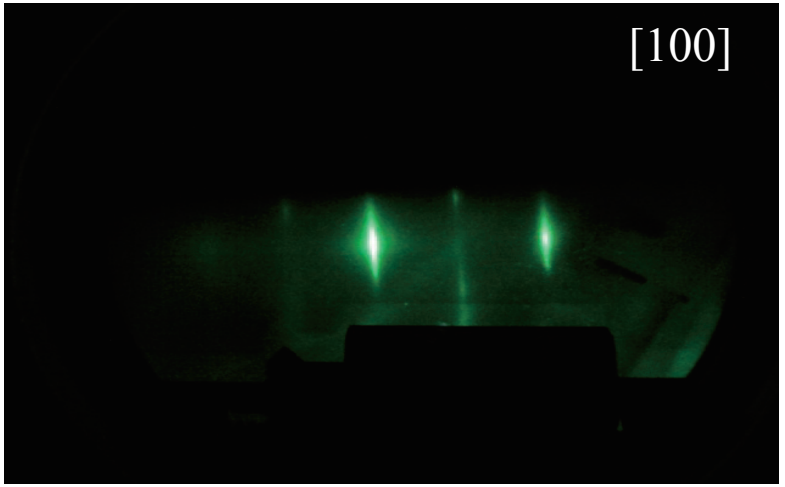
Narrow-gap material
- epitaxial solar cells on Ge substrate
- novel narrow-gap material

Experimental

Growth method: conventional Molecular beam epitaxy
Sources: Cu(7N), In (7N), Se(6N)
Substrate: Ge (001)
Growth temperature: 450℃
Cu/In ratios: γ=0.4-2.2(changing the In beam flux)
Substrate etching solution: 1HF:1H_2O_2:30H_2O
Thermal cleaning process : 640℃
Characterization: XRD, RHEED, SEM,EPMA

<RHEED patterns from thermal clean Ge(001) surface>

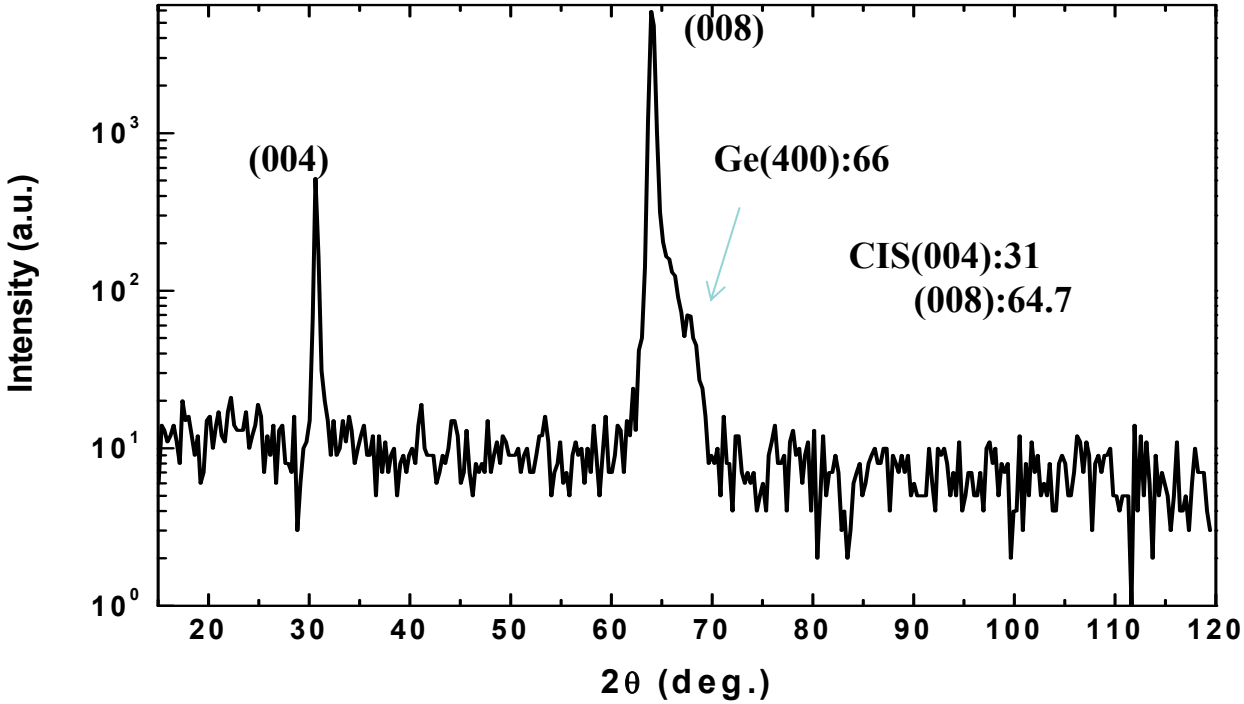


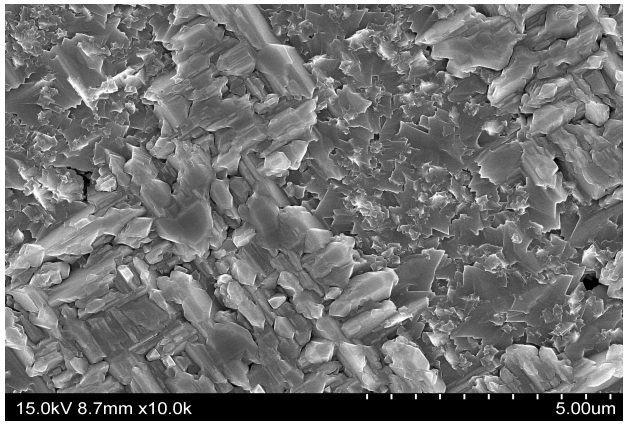


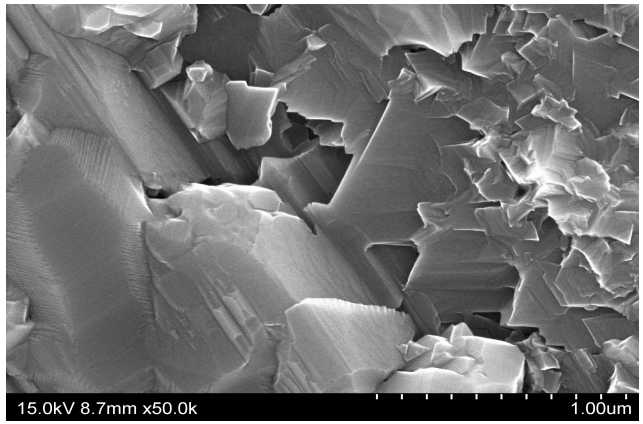
Results

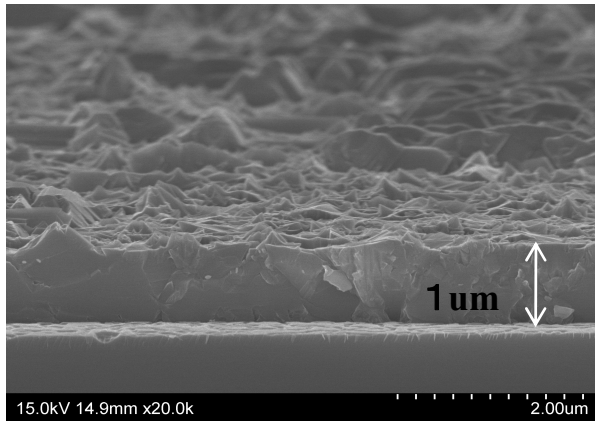
In:745 ℃ 2.2×10^{-7}
Cu:1005 ℃ 1.1×10^{-7}
T_{sub} : 450℃

EPMA (Cu/In)
5kV :0.85
7kV :1.07
15kV :1.19



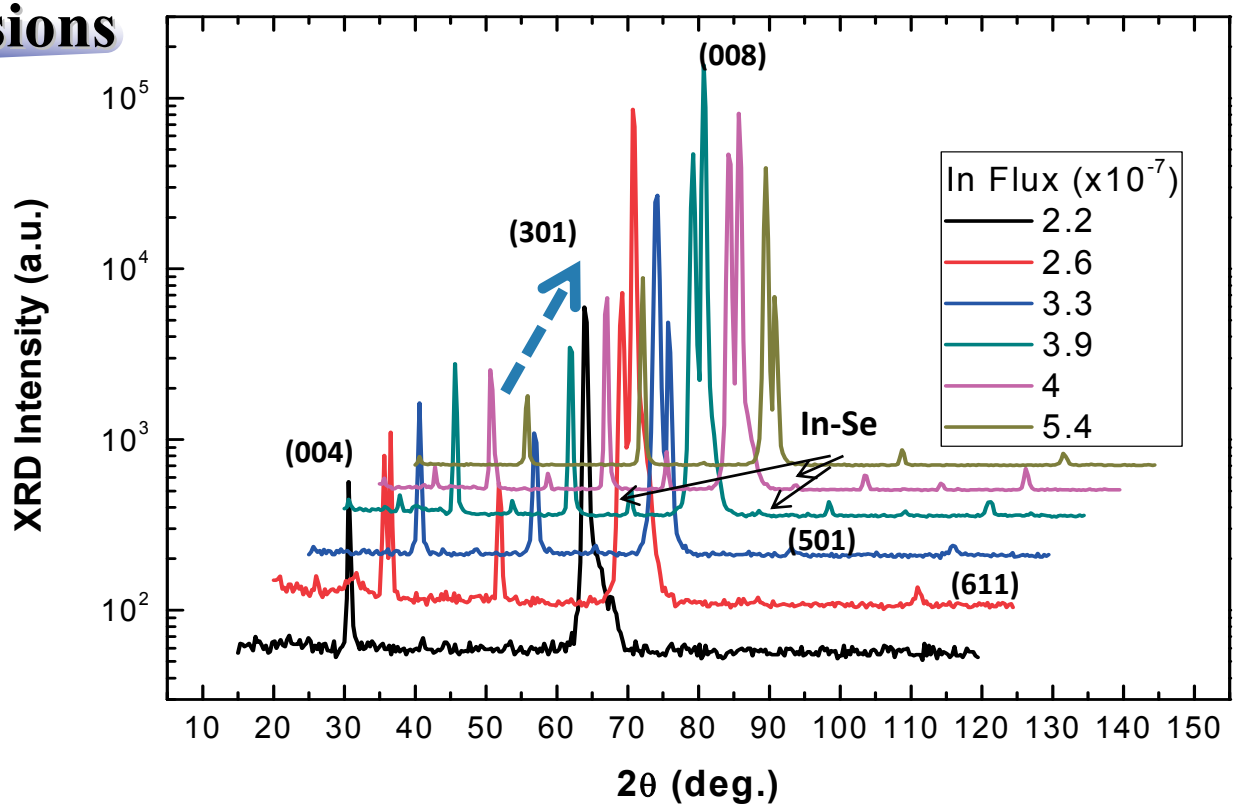






Near stoichiometric CIS film was not observed second phase

Conclusions



$CuInSe_2$ (CIS) films with Cu/In ratios of γ=0.4-2.2 have been grown on (001)-oriented Ge substrates by molecular beam epitaxy at substrate temperature of T_s=450℃.

***In situ* RHEED analysis indicated the epitaxial growth as well as the chalcopyrite structure.**

RHEED patterns along the [-100] direction showed the spots characteristic of the chalcopyrite structures, also indicating the c-axis normal to the substrate.

No secondary phase detected in XRD at Cu-rich and near stoichiometric but In-rich CIS films were observed.