Epitaxial growth of $Cu(In,Ga)S_2$ thin films on GaP/Si(001) pseudo-substrate: towards $Cu(In,Ga)S_2$/Si tandem solar cells

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In the family of $Cu(In,Ga)(S,Se)_2$ compounds, pure-sulfide $Cu(In,Ga)S_2$ (CIGSu) attracts much attention as its bandgap may be tuned from 1.54 (for $CuInS_2$) to 2.43 eV (for $CuGaS_2$) [1], making it suitable both for single-junction as well as tandem solar cells. Namely, partnered with a crystalline Si (c-Si) bottom cell in a tandem context, $CuIn_{0.75}Ga_{0.25}S_2$ displays a near ideal bandgap of 1.7eV for a top cell absorber. In addition, it shares crucial similarities with GaP and Si in terms of crystal structure and lattice parameters (as shown in Fig. 1).

However, CIGSu solar cells still suffer from low output voltage as compared to their selenide counterparts. This deficit is partly explained by the more complex chemistry of CIGSu [2] as well as higher bulk and interface recombination activity [3]. One improvement pathway to increase minority carrier lifetime consists in eliminating extended crystalline defect, like grain boundaries, where chemical fluctuations may introduce recombination centers [4].

The epitaxial integration of CIGSu on GaP/Si substrate allows enhancing the crystalline quality of the CIGSu bulk; additionally, it paves the way for adherent monolithic integration CIGSu top cells onto c-Si bottom cells, in a two terminal configuration. In parallel, experimental work on CIGSu/GaP/Si mono-junction solar cells aims at understanding the performances of GaP as a back contact for CIGSu, as well as a potential interconnecting layer.

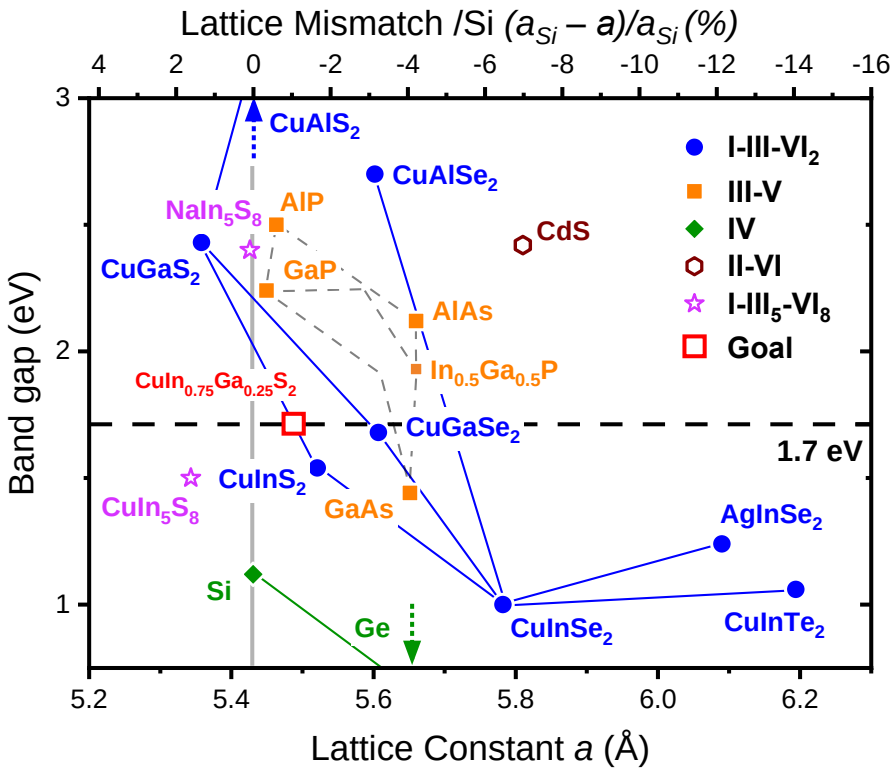

Figure 1: Band gap vs lattice mismatch for chalcopyrite I-III-VI$_2$, group IV, II-VI and III-V semiconductors, whose crystal structures share important similarities. Gallium phosphide GaP is quasi lattice matched with Si. Alloys with the approximate composition $CuIn_{0.75}Ga_{0.25}S_2$ have near ideal band gap for top cell applications and suitable lattice parameter for epitaxial growth on Si and GaP. Lattice mismatch relative to Si, is represented on the top x-axis scale.

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