OPTIMIZATION OF WATER-BASED SYNTHESIS OF CIGSE NANOPARTICLES FOR SOLAR TEXTILES

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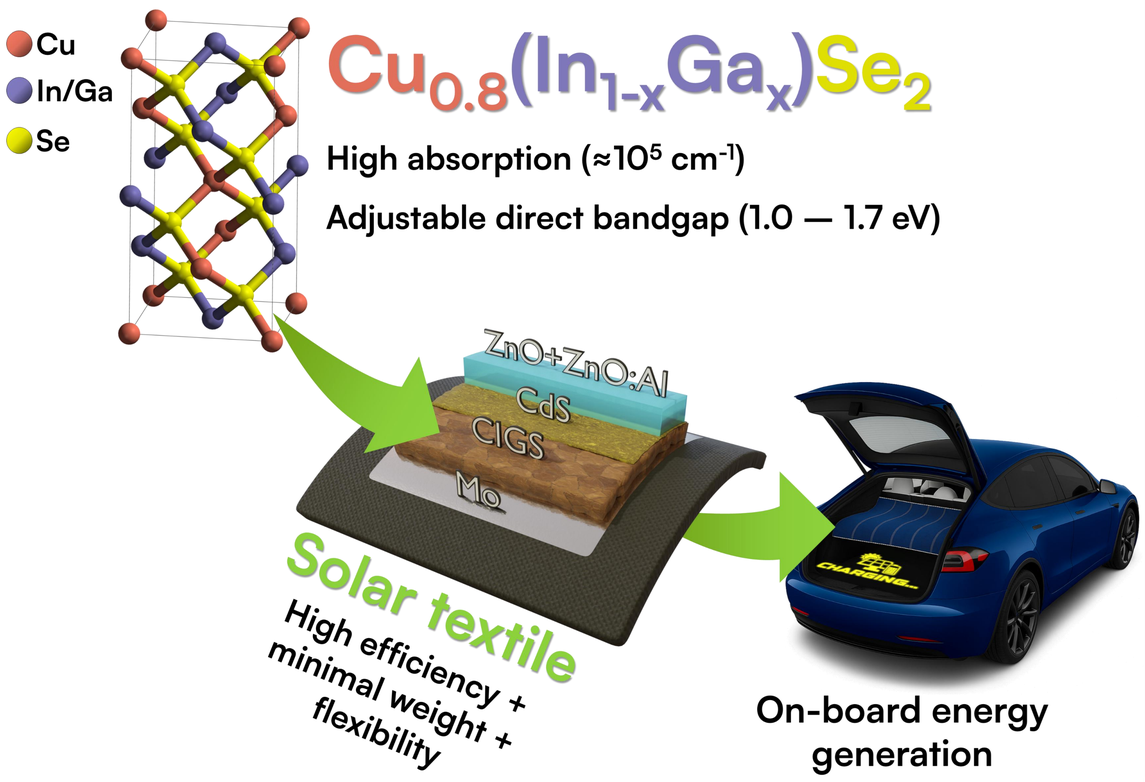
Introduction

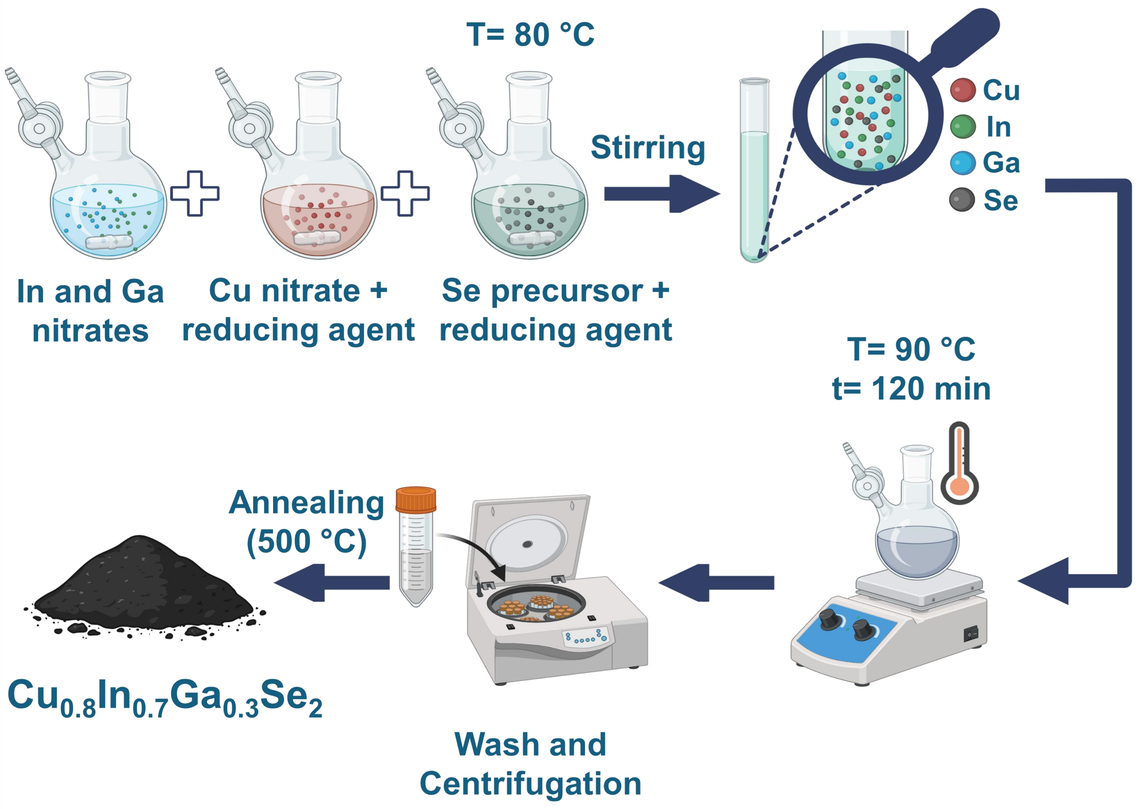
- **Promising material:** CIGSe thin-film solar cells are ideal for flexible applications[1,2].
- **Sustainable synthesis[3]:** Solution-based method produces crystalline nanoparticles without vacuum or post-selenization.
- **Scalable production:** Nanoparticles can be made into printable inks for large-scale manufacturing.

Application: Photovoltaic cell on textile for integration into EVs



Methods

Water-based synthesis



- Several parameters were studied:
  - Reducing agent for $Cu(NO_3)_2{\cdot}(H_2O)_x$: L-gluthatione reduced (GSH) or ascorbic acid.
  - Se source: Na_2SeO_3 or Se, and reaction temperature.
  - Annealing time and gas atmosphere composition.

Results & Discussion

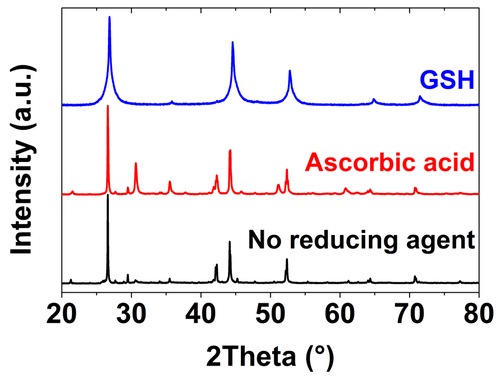
Synthesis optimization

- GSH as the Cu reducing agent was essential to produce crystalline CIGSe, without formation of secondary compounds.
- Influence of Se source material:

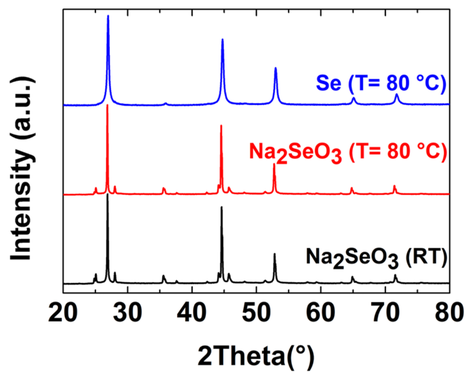
  Na_2SeO_3 → secondary phases formation.

  Se powder → chalcopyrite CIGSe.

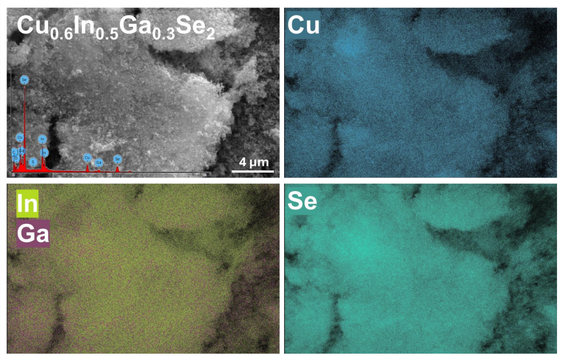
Cu^{2+} → Cu^+ reduction



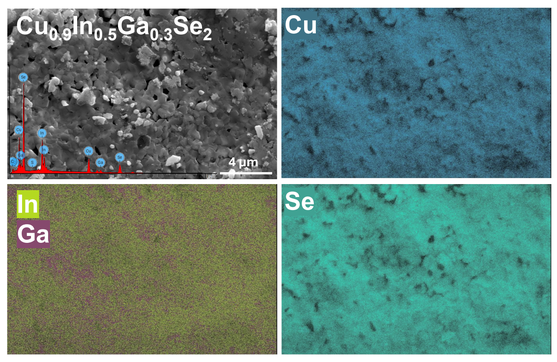
Se precursor and impact of temperature



Unoptimized

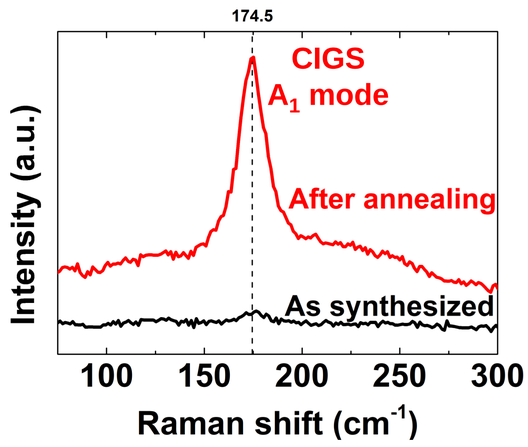


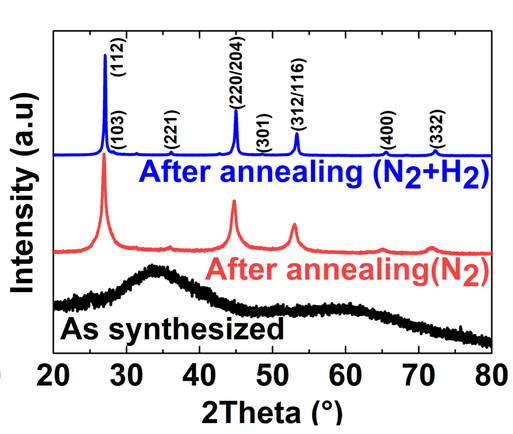
Optimized

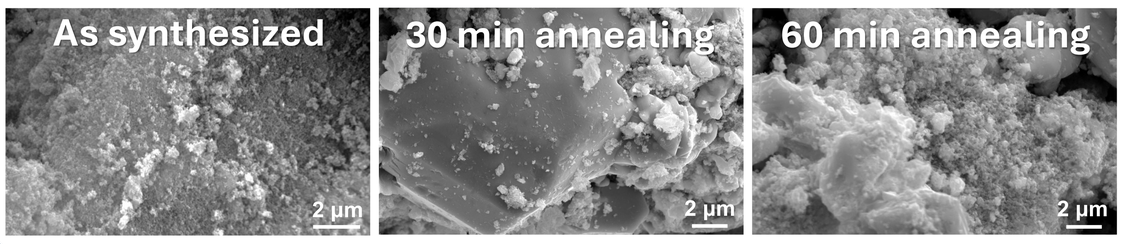


Annealing optimization

- Amorphous → crystalline transformation after annealing at 500 °C.
- Enhanced crystallinity under reducing atmosphere (95% N_2 + 5% H_2).
- No Cu_2Se detected.







Conclusions

- Successful solution-based synthesis of crystalline CIGSe particles using water as solvent.
- Elimination of unwanted secondary compounds and increase of NPs crystallinity.
- Several grams production per batch with straightforward scalability for larger quantities.
- Suitable for ink formulation and screen-printing deposition methods.

References

1) S. Minoura et al., Dielectric function of $Cu(In,Ga)Se_2$-based polycrystalline materials, J Appl Phys 113 (2013).

2) J.E. Jaffe, A. Zunger, Electronic structure of the ternary chalcopyrite semiconductors $CuAlS_2$, $CuGaS_2$, $CuInS_2$, $CuAlSe_2$, $CuGaSe_2$, and $CuInSe_2$, Phys Rev B 28 (1983).

3) B.F. Gonçalves et al., Large-scale aqueous synthesis of $Cu(In,Ga)Se_2$ nanoparticles for photocatalytic degradation of ciprofloxacin, Dalton Trans. 50 (2021).

Acknowledgements

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