

# Quantitative strain mapping in semiconductors by 4D STEM

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$\text{Zn}_3\text{P}_2$  is a promising photovoltaic material due to its near-ideal bandgap ( $\sim 1.5$  eV), strong optical absorption, and composition of earth-abundant, non-toxic elements. Achieving high device performance, however, requires precise control over local crystal structure and strain, particularly in thin film geometries where microstructural variations influence carrier transport and recombination. To probe these effects at the nanoscale, we employed 4D Scanning Transmission Electron Microscopy (4D STEM) with energy-filtered diffraction acquisition, enabling quantitative mapping of crystal orientation, strain, and defects across large fields of view. With this approach, we investigated monocrystalline  $\text{Zn}_3\text{P}_2$  thin films in the as-grown state and after annealing at different temperatures. The films grown by Selective Area Epitaxy on InP exhibit subtle in-plane misorientations revealed by low-magnification 4D STEM orientation mapping. These misorientations manifest as rotated domains extending through the film thickness, indicating minor domain misalignment within an otherwise coherent epitaxial structure. Together, these observations demonstrate the sensitivity of 4D STEM to subtle orientation variations and highlight the importance of understanding domain structure and strain evolution for optimizing growth strategies and improving structural quality. These results highlight the applications of energy filtered 4D STEM in semiconductor characterization and demonstrate its role as a practical tool for probing strain, domain structure, and crystalline uniformity across a range of semiconductor materials.

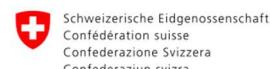
*This project has received funding from the European Innovation Council and SMEs Executive Agency (EISMEA) under grant agreement No 101046297 Funded by the European Union. Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union or European Innovation Council and SMEs Executive Agency (EISMEA). Neither the European Union nor the granting authority can be held responsible for them. This work was supported by the Swiss State Secretariat for Education, Research and Innovation (SERI) under contract number 22.00018.*



Funded by  
the European Union



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Council



Schweizerische Eidgenossenschaft  
Confédération suisse  
Confederazione Svizzera  
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## References

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