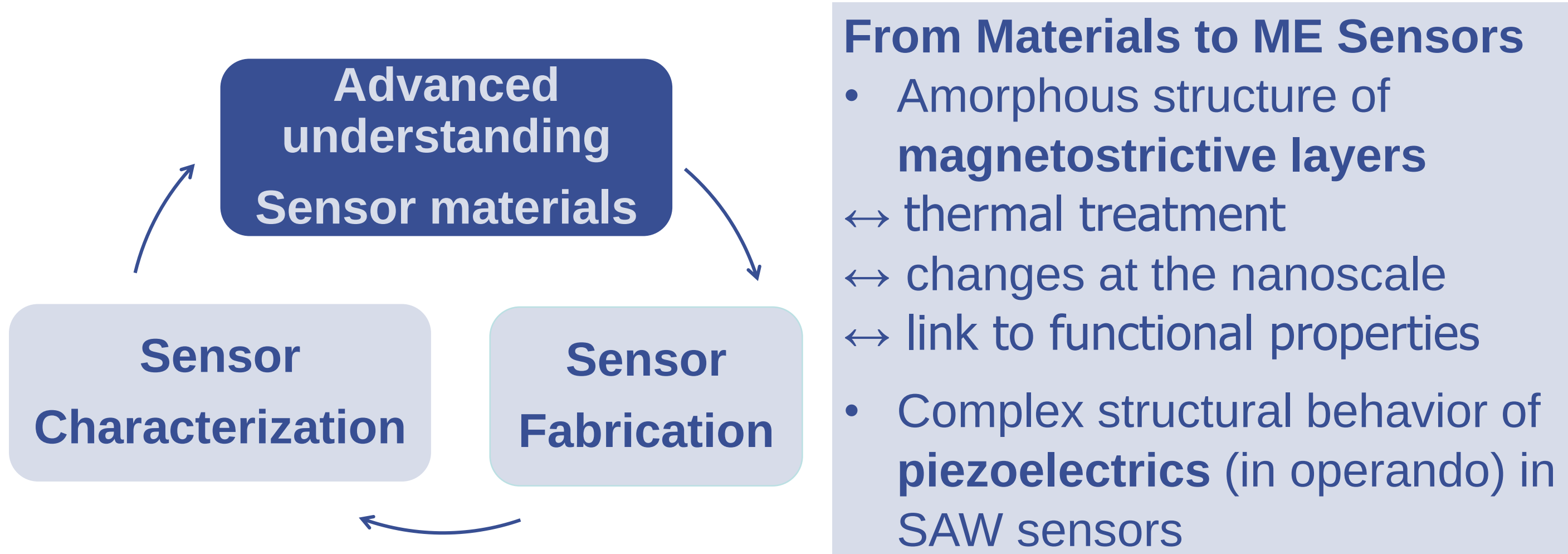


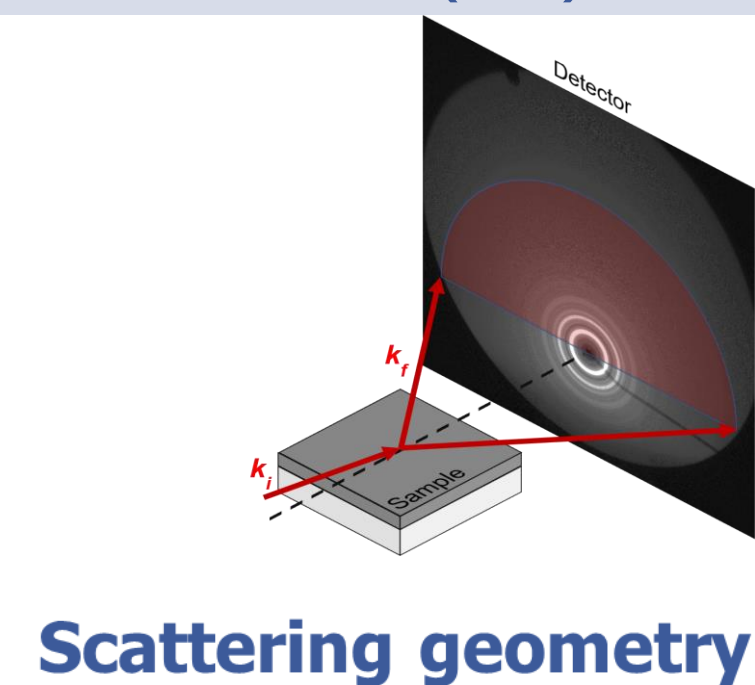
Motivation and Objectives



Results of the Second Funding Period

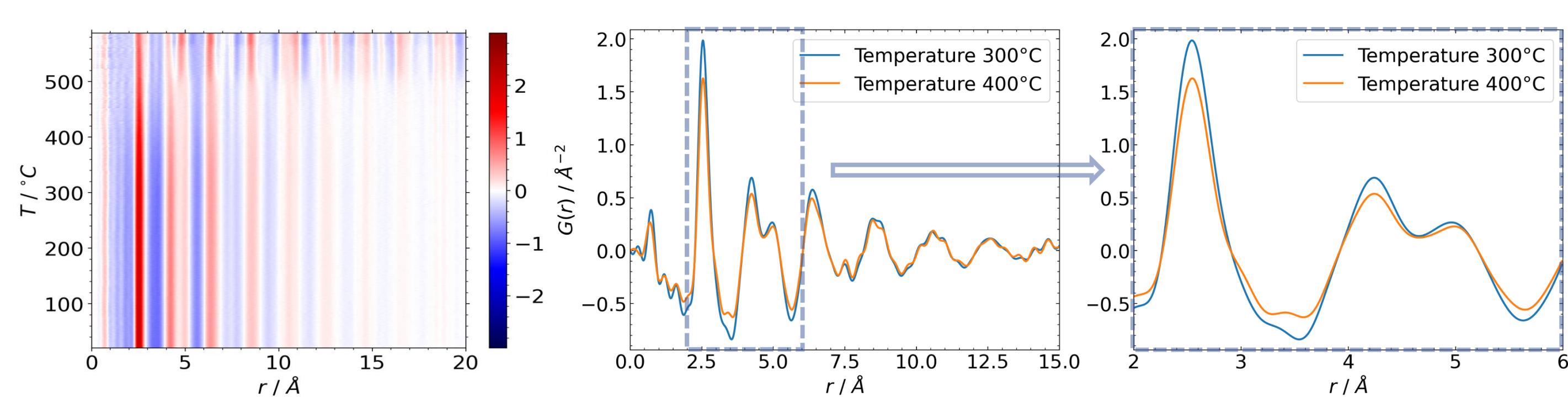
Time-resolved *in situ* X-ray total scattering on FeCoSiB films (A1)

- Time/temperature resolved Pair Distribution analysis
- Initial onset of structural changes around 330°C
- Two crystallization transitions:
 - Gradual first transition with α -Fe-formation
 - Second transition with Fe_2B formation at 560°C



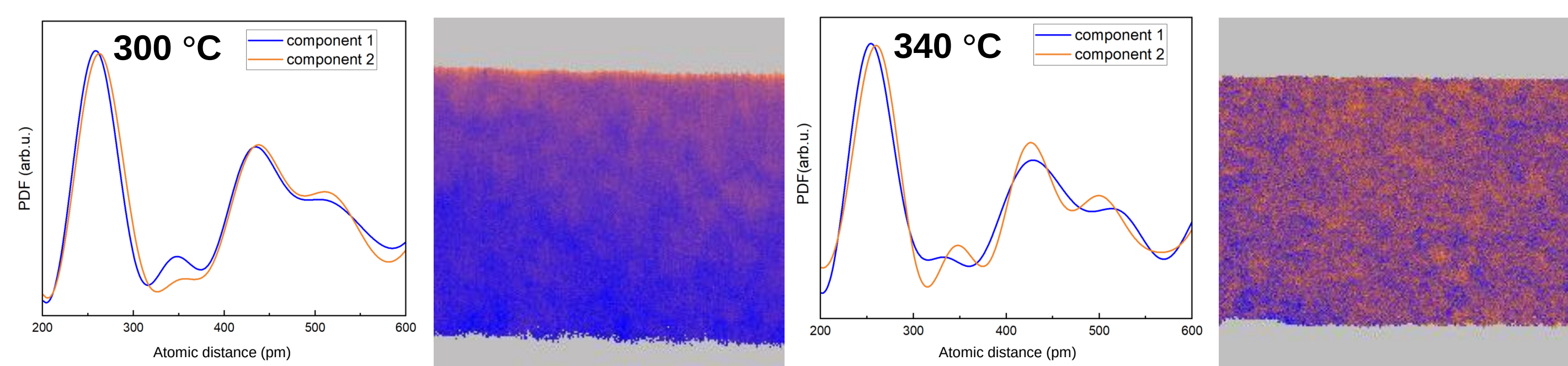
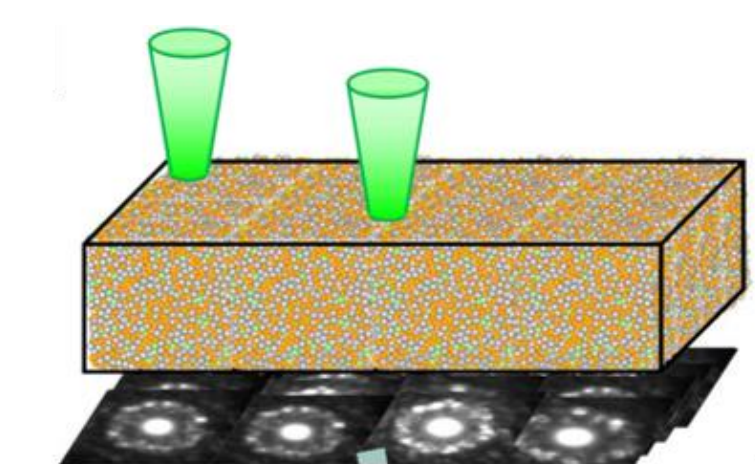
Scattering geometry

PDF 50 nm FeCoSiB



Structural changes in FeCoSiB before crystallization (A1)

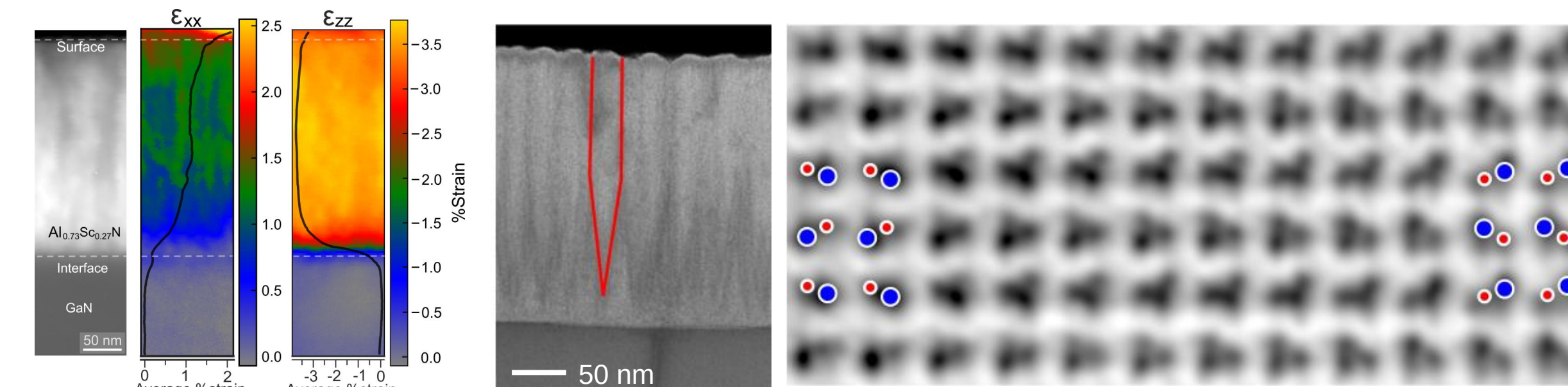
- 4D-STEM Analysis of Radial Distribution Function in amorphous magnetostrictive layer
- Machine learning approach^[1]: Identification and localization of component with increased density



[1] S. Kang, V. Wollerssen, C. Minnert, K. Durst, H.-S. Kim, C. Kübel, X. Mu, Acta Materialia 2024, 263, 119495.

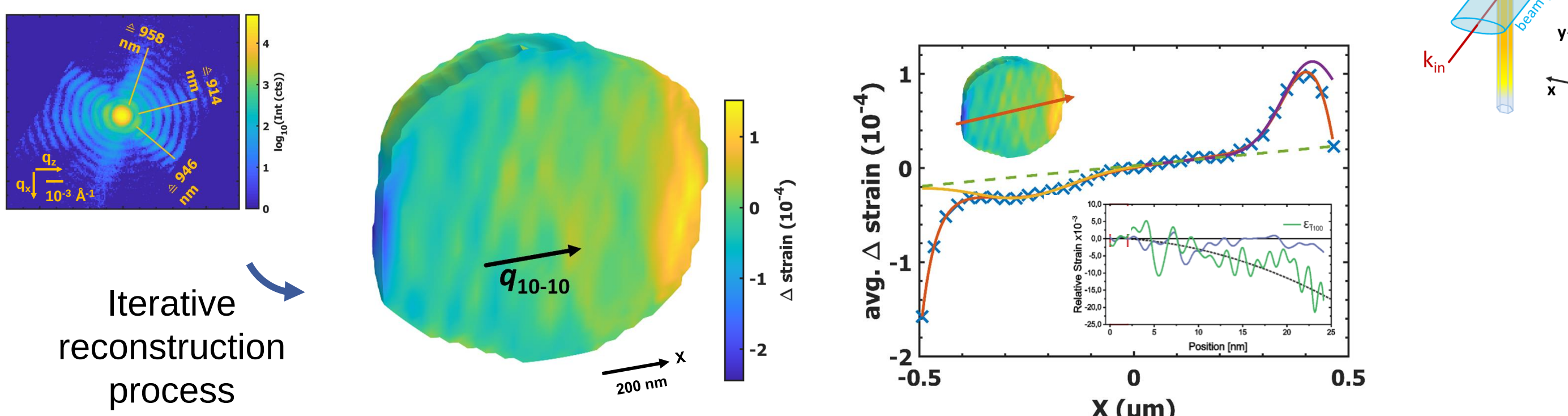
Analyses of strain, atomic structure and polar domains in AlScN (A7/A9)

- Quantification of interfacial strain by 4D-STEM
- ABF-STEM investigation of polar domain patterns and boundaries



Coherent X-ray diffraction imaging (CXDI) of strain at interfaces of piezoelectric composites (A5E)

- Strain imaging of Au coated ZnO rod $\rightarrow$ Schottky contact
- Distinct strain at interface and in volume



Work Plan for Third Funding Period

Research methods

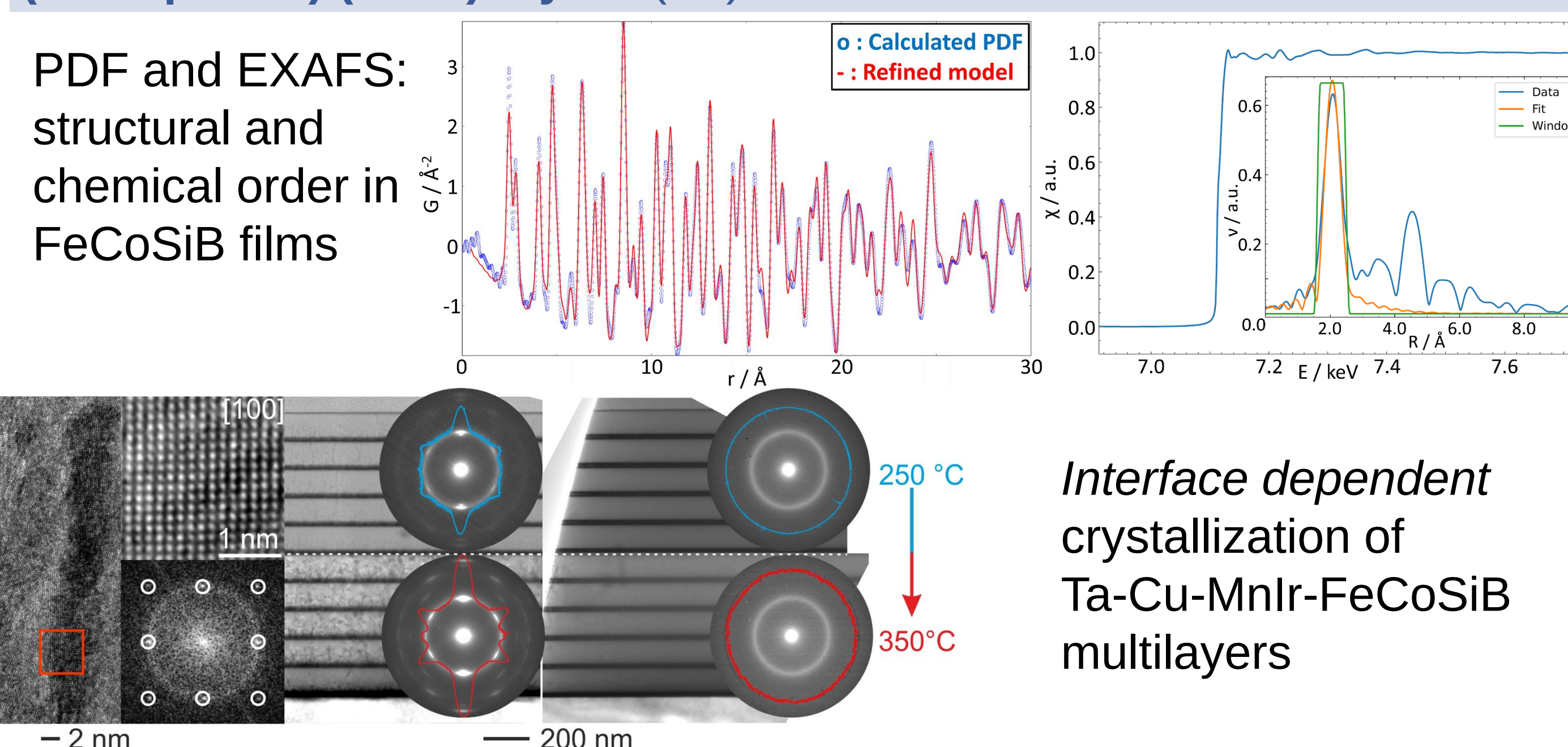
In situ and *in operando* techniques

Amorphous material
4D STEM & Synchrotron-PDF

Crystalline material
HR(S)TEM & nano-XRD, GID

WP1/WP2 *Ex situ/In situ* Real Structure Investigations of (Amorphous) (Multi)Layers (A1)

PDF and EXAFS:
structural and
chemical order in
FeCoSiB films



Interface dependent
crystallization of
Ta-Cu-MnIr-FeCoSiB
multilayers

WP3 *Ex situ* investigation of AlScN structures for SAW sensors (A9)

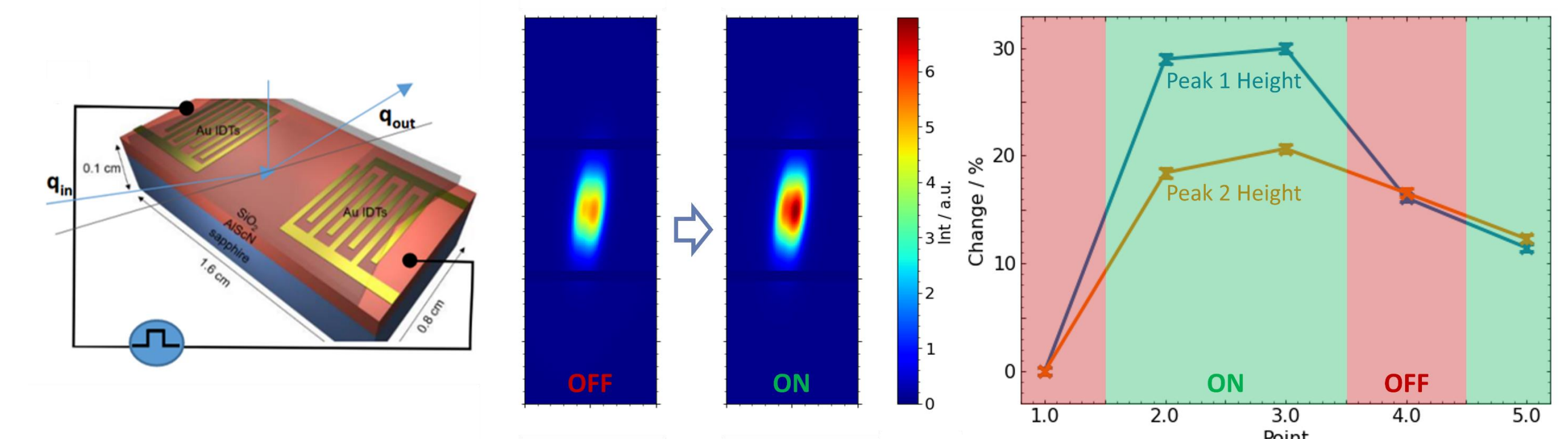
- Focus on crystalline texture, interfacial strain, polar domain structures

WP4 Imaging of acoustic wave propagation in AlScN SAW sensors

- Focus on perturbations related to defects, strain and texture

WP5 *In operando* examination of depth-dependent strain in AlScN during excitation of SAW modes (A9)

- Development of *in operando* measurements $\rightarrow$ time-resolved change



	Kienle		Murphy		2024		2025		2026		2027		2028	
	3	4	1	2	3	4	1	2	3	4	1	2	3	4
WP1 – <i>Ex situ</i> examination of amorphous magnetostrictive (multi)layers														
WP2 – <i>In situ</i> examination of amorphous magnetic (multi)layers														
WP3 – Real structure examination of AlScN thin film SAW sensors														
WP4 – Imaging of surface acoustic wave propagation in AlScN thin film sensors														
WP5 – <i>In Operando</i> examination of depth-dependent strain during excitation of SAW														

Collaborations

A1: Investigation of nanoscale structure of magnetic multilayer systems

A2: Nanoscale analysis of electret sensor components

A4: (Amorphous) structure $\leftrightarrow$ process parameters in FeCoSiB deposition

A7/9: Structure of piezoacoustic and magnetostrictive components

A8: Photonic structures for SAW sensors

A10: Input of morphological parameters for suitable submodels

Z1: Advanced characterization of sensor materials to improve fabrication technology

B12(N): TEM analysis of functionalized magnetic nanoparticles

Participation in focus groups: F1: Magnetic Layers, F2: Sensor Modelling, F4: Magnetoelectric Sensors

Funds Requested

1 Postdoctoral researcher (100%), 1 Doctoral researcher (75%), consumables: 64.8 k€

[A6-1] Jordt, P., Wolff, N., Hrkac, S. B., Shree, S., Wang, D., Harder, R. J., Kübel, C., Adelung, R., Shpyrko, O. G., Magnussen, O. M., Kienle, L., & Murphy, B. M.: (2021) Advanced Electronic Materials, 7(11), 2100546. (open access). – A5, A6

[A6-2] Jordt, P., Hrkac, S. B., Gröttrup, J., Davydok, A., Krywka, C., Wolff, N., Kienle, L., Adelung, R., Magnussen, O. M. & Murphy, B. M.: (2021) Advanced Engineering Materials, 23(11), 2100201. (open access). – A5, A6

[A6-3] Wolff, N., Jordt, P., Braniste, T., Popa, V., Monaico, E., Ursaki, V., Petraru, A., Adelung, R., Murphy, B. M., Kienle, L., Tiginyanu, I.: (2019) ECS Journal of Solid-State Science Technology, 8(8), 141–146 (open access). – A5, A6

[A6-4] Wolff, N., Jordt, P., Jetter, J., Vogt, H., Lotnyk, A., Seemann, K., Ulrich, S., Quandt, E., Murphy, B. M. & Kienle, L.: (2021) Materials Characterization, 172, 110871. – A1, A6

[A6-5] Sartori, A., Giri, R.P., Fujii, H., Murphy B.M., Magnussen O.M.: (2022) Nat Commun 13, 5421 (open access).

[A6-6] Mandal P., Giri R.P., Murphy B.M., and Ghosh S.K.: (2021) ACS Applied Materials & Interfaces 13 (48), 57023-57035. – A6

[A6-7] Schönweger, G., Petraru, A., Islam, M. R., Wolff, N., Haas, B., Hammud, A., Koch, C., Kienle, L., Kohlstedt, H., & Fichtner, S.: (2022) Advanced Functional Materials, 32(21), 2109632 (open access). – A6

[A6-8] Wolff, N., Fichtner, S., Haas, B., Islam, M. R., Niekel, F., ... & Kienle, L.: (2021) Journal of Applied Physics, 129(3). – A6

[A6-9] Koops, C. T., Hrkac, S. B., Abes, M., Jordt, P., Stettner, J., Petraru, A., Kohlstedt, H., Hrkac, V., Wolff, N., Kienle, L., ... & Murphy, B. M.: (2020). In 4th International Conference on Nanotechnologies and Biomedical Engineering: Proceedings of ICNMBE-2019, September 18-21, 2019, Chisinau, Moldova (pp. 187-191). Springer International Publishing. – A6

[A6-10] Abes, M., Koops, C.T., Hrkac, S.B., Greve, H., Quandt, E., Collins, S.P., Murphy, B.M. and Magnussen, O.M.: (2013) Applied Physics Letters, 102(1), 011601. – A6