**Invitation to the talk by Dr.-Ing. Andreas Warkentin at the GAMM Junior Research Group Christmas Party**

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| Place: | R165 (hybrid)<br>Zoom Link: Link<br>Meeting ID: 919 9415 3853<br>Passcode: ferro |
| Date: | Thursday, 12th December 2024 |
| Time: | 4:00 pm (16:00) |

**Agenda**

*TOP 1:* Seminar by Dr.-Ing. Andreas Warkentin (see abstract below)

*TOP 2:* Discussion and Questions

*TOP 3:* Open Exchange and Christmas Party including drinks and food

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# Efficient energy harvesting with ferroelectrics: from material modeling to process optimization

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Ferroelectrics exhibit many interesting effects, both linear and nonlinear, which is why they are widely used in science and technology. Generally, these materials have been employed as energy harvesters, however in this context, they are more famous for their linear effects than their nonlinear ones, not least because the latter are accompanied by energy dissipation, which invariably leads to heat generation and damage. Recently, the utilization of nonlinear effects in the field of energy harvesting has been gaining momentum and is called ferroelectric/ ferroelastic energy harvesting [1, 2, 3]. The latter comprises cyclic processes, wherein the external electromechanical loads are arranged such that at appropriate stages the material is systematically de– and repolarized. Due to the actively induced switching processes, the problem of unintended depolarization and thus functional degradation due to purely mechanical load, as in piezoelectric energy harvesting, is avoided.
A common approach is to use a mechanical input that causes the depolarization of the material against an electrical field, resulting in a substantial amount of electric output. Taking advantage of comparatively large changes of strain and polarization due to domain switching, the electric output is higher compared to what is commonly known as piezoelectric energy harvesting. Dissipative self–heating and augmented damage accumulation, on the other hand, may impede the operability of the harvesting device, in particular if tensile stress is required for depolarization, as suggested by recent works [1, 2]. A new harvesting cycle [3] thus dispenses with tensile stresses and instead exploits the potential of existing residual stresses. It is further investigated to which extent a bias field, commonly applied to support repolarization as an important stage of the cycle, can be omitted, saving considerable effort on the technical implementation. Process parameters are obtained from various simulations by pareto–optimization, considering, inter alia, the effect of ambient temperature.

## REFERENCES

[1] W. Kang, L. Chang and J. E. Huber, Nano Energy 93 (2022), 106862

[2] L. Behlen, A. Warkentin and A. Ricoeur, Smart Mater. Struct. 30 (2021), 035031

[3] A. Warkentin, L. Behlen and A. Ricoeur, Smart Mater. Struct. 32 (2023), 035028

# Andreas **Warkentin**

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## Employment

02.2024 – 11.2025 — PostDoc, University of Kassel
Institute of Mechanics, Engineering Mechanics/ Continuum Mechanics

2018 – 01.2024 — Research Associate, University of Kassel
Institute of Mechanics, Engineering Mechanics/ Continuum Mechanics

## Education

2018 – today — PhD Candidate at University of Kassel
Institute of Mechanics, Engineering Mechanics/ Continuum mechanics
PhD supervisor: Prof. Andreas Ricoeur

2017 – 2018 — M.Sc. Mechanical Engineering, University of Kassel
Thesis: *Erweiterung der Kondensierten Methode zur numerischen Analyse polykristalliner Ferroelektrika durch Berücksichtigung nichtlinearer bilateraler kalorisch-elektromechanischer Kopplungen*

2014 – 2017 — B.Eng. Mechanical Engineering, University of Applied Sciences Gießen
Thesis: Experimentelle und numerische Untersuchung des Wedge-Impact-Peel-Versuchs unter Berücksichtigung des Temperatureinflusses auf ein zähmodifiziertes Klebstoffsystem

## Scientific Publications

2023 — European Journal of Mechanics and Solids – A/ Solids
*Scale transition and residual fields in modeling of polycrystalline ferroelectrics based on the internal energy potential and a Voigt-Reuss approximation*

2022 — Smart Materials and Structures
*Model-based investigations of ferroelectric energy harvesting with regard to an improvement of life span and operability*

2022 — Proceedings in Applied Mathematics and Mechanics
*Hybrid modeling of viscoelastic and switching-induced heating in ferroelectrics*

2021 — Smart Materials and Structures
*Exploiting ferroelectric and ferroelastic effects in piezoelectric energy harvesting: theoretical studies and parameter optimization*

2021 — Proceedings in Applied Mathematics and Mechanics
*Experimental investigations of viscoelastic and ferroelastic heating in PZT-5H*