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Elastocaloric cooling from miniature scale to macro scale

Elastocaloric cooling is an emerging solid-state cooling technology that promises environmentally friendly and energy-efficient alternatives to traditional vapor-compression systems. This talk presents recent advancements in elastocaloric cooling devices at Karlsruhe Institute of Technology, spanning from miniature to macro-scale implementations.

At the miniature scale, we utilize superelastic SMA films, which combine a high elastocaloric effect with efficient heat transfer due to their large surface-to-volume ratios. We conduct thorough thermomechanical characterization of these SMA films and assess device performance in terms of temperature span, cooling power, and coefficient of performance (COP). Different configurations are benchmarked, including single-device systems, parallel architectures for enhanced cooling power, and cascade architectures to increase the achievable temperature span. We further report the development of an ultra-high-lifetime elastocaloric microcooling device employing ultra-low-fatigue TiNiCuCo films. These devices exhibit exceptional durability—exceeding 107 cycles—achieved through the use of TiNiCuCo films, optimized mechanical fixation strategies, refined film designs, and adaptable loading mechanisms that collectively enhance system reliability and extend operational lifespan.

At the macro scale, we propose a novel regenerator architecture based on porous woven structures. Unlike conventional tube-based designs, this architecture offers a significantly higher surface-area-to-volume ratio, which enhances heat transfer and overall system efficiency.

1. K. Wang, M. Kohl, J. Xu*. Numerical study of enhanced cooling in active elastocaloric regenerators with porous woven structures. Applied Energy. Accepted.

2. J. Xu, F. Bruederlin, L. Bumke, H. Ossmer, E. Quandt, S. Miyazaki, and M. Kohl. (2024). SMA film-based elastocaloric cooling devices. Shape Memory and Superelasticity, 10(2), 119–133. <https://doi.org/10.1007/s40830-024-00484-y>