ACTIPIPE: SUSTAINABLE COOLING CONCEPTS - ACTIVE HEATPIPES FOR ENVIRONMENTALLY FRIENDLY AND EFFICIENT COOLING

Today, nearly all refrigeration and air conditioning systems are based on conventional compressor technology, which requires refrigerants for operation. However, this technology has several serious disadvantages: All refrigerants used today have a more or less large Global Warming Potential (GWP). Despite appropriate recycling regulations, enormous amounts of refrigerants are disposed of in the atmosphere. According to a study of the Deutsche Umwelthilfe, the corresponding global warming potential of these refrigerants encounters 5.9 million tons of CO_2, which is as much as the entire car traffic in Saxony. Besides these negative environmental impacts, low efficiency, noise emission and reduced lifetimes are further disadvantages of today's compressor technology.

The goal of the project ActiPipe is the investigation of the basics of a new cooling technology based on a combination of heatpipes with magnetocaloric materials (patent pending). Heatpipes are able to transfer heat very efficiently without the need of pumps by exploiting vaporization and condensation enthalpy. At the same time, heatpipes can be designed to act as a thermal diode, which means that heat is always transported in one direction.

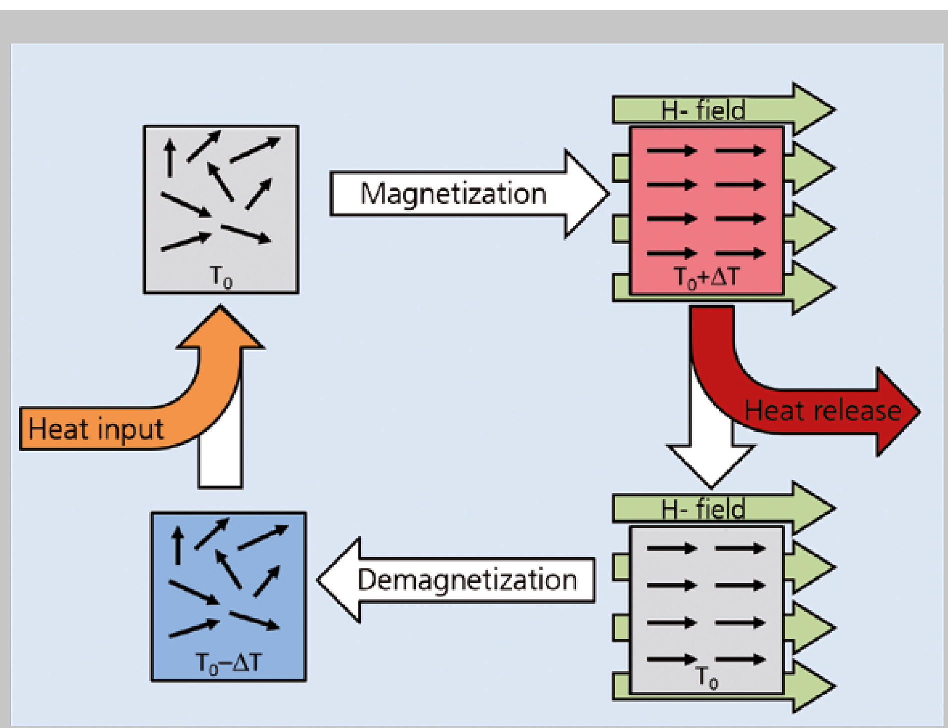


Figure 1: The principle of magnetocaloric cooling.

Magnetization: Magnetocaloric (MC) material is exposed to a magnetic field and heats up due to the generated magnetic order from temperature T_0 to $T_0+\Delta T$.

Heat release: The MC-material is connected to a heat sink; the heat produced can be dissipated, the MC material cools down again to temperature T_0.

Demagnetization: If the magnetic field is removed, the MC-material cools down and is at a lower temperature $T_0-\Delta T$ than it is at the start of the cycle.

Heat input: The MC-material is now connected to the system to be cooled and can absorb heat until it reaches temperature T_0 again.

By combining magnetocaloric materials with heatpipes, an "active heatpipe" can be realized, which actively heats against a thermal gradient. Magnetocaloric (MK) materials heat up by ΔT when exposed to a magnetic field and cool down by ΔT again as soon as the field is turned off. This allows the realization of a cooling cycle, see Figure 1.

Overall, cooling systems based on magnetocaloric materials have a number of inherent benefits compared to conventional compressor technology:

- Efficient – an increase in efficiency of 20 – 30 percent is possible compared to conventional systems.
- Green – no environmentally harmful refrigerants are required.
- Low maintenance – no wear parts
- Silent – can be used anywhere

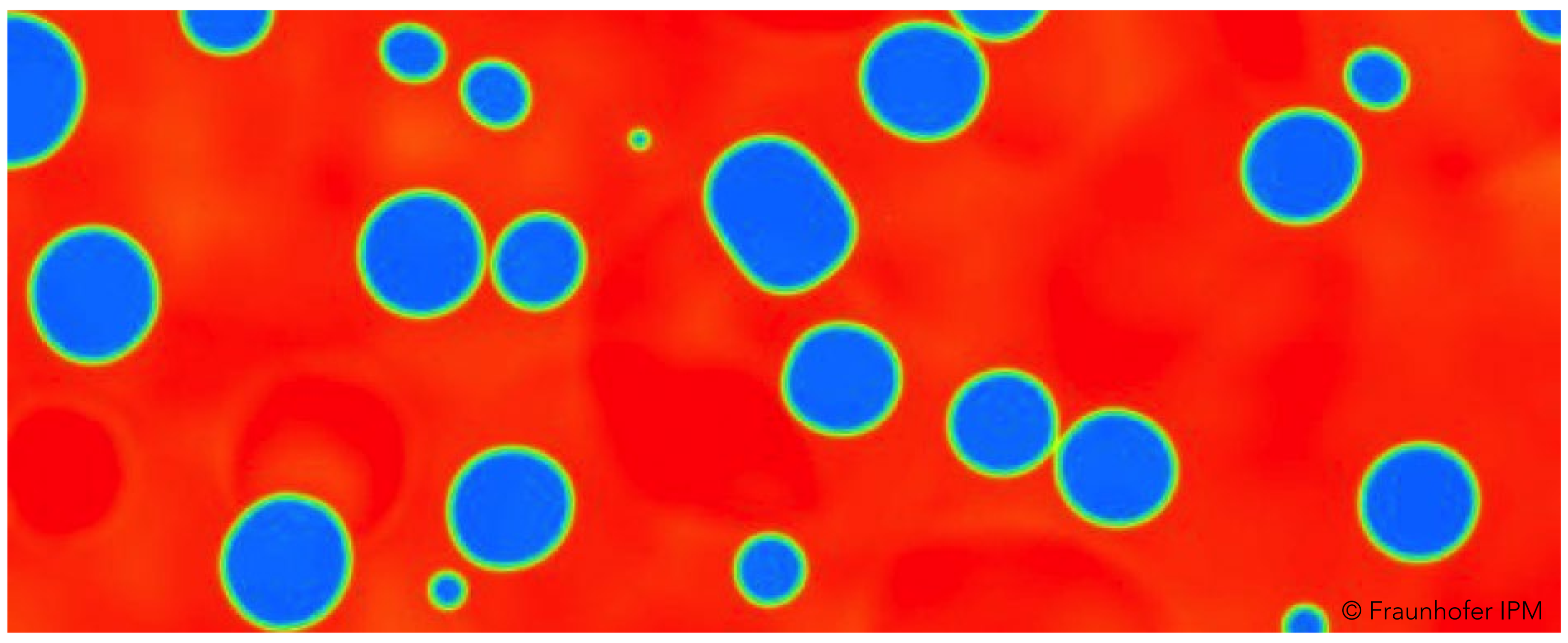
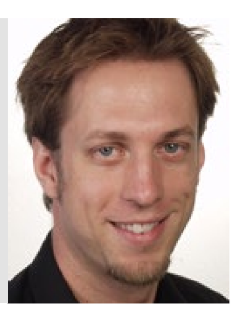


Figure 2: Results of a simulation of the behavior of a two-phase fluid.

These properties, the highly efficient transport of heat and the function as a thermal diode are exploited in the project ActiPipe in order to build refrigerant-free, highly efficient cooling systems based on magnetocaloric materials.

For optimum design of an active heatpipe, a detailed understanding of the underlying processes is mandatory. Therefore, the Department of Applied Mathematics of the Albert-Ludwigs-Universität Freiburg establishes a simulative description of the fluid-dynamic processes in an active Heatpipe. In parallel, Fraunhofer IPM builds and characterizes these systems in order to test and verify simulations. Thereby the partners set the scientific basis for the later construction of highly efficient, refrigerant-free air conditioning systems based on magnetocaloric materials.

Contact



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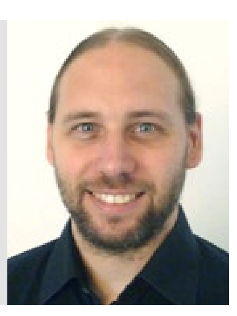

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