Focus Efficient thermal switches

Heat pipe-based thermal switches can switch and control heat flows very efficiently.

We're using hydrophilic sorbents to develop new concepts for heat pipe-based thermal switches.

Temperature control without sensor technology or control engineering

Regulating the temperature of components in the fields of electromobility, battery technology and mechanical engineering becomes increasingly important as power density rises. Fraunhofer IPM is developing a new generation of thermal switches using switchable heat pipes, which provide an autonomous and efficient heat management system – without complicated sensor technology or control engineering. Using a switchable heat pipe, temperature control requirements can be substantially reduced in many systems.

More efficient heat flux regulation

Using thermal switches, heat flux can be activated, deactivated and regulated – quite similar to common electric switches. Conventional designs for thermal switches have several disadvantages: When in the "on" position, the thermal resistance is high, and the switches are large, often with a complex design and containing moving parts. For more widespread use, thermal switches must also become more efficient and cost-effective.

New thermal switch design

Fraunhofer IPM is collaborating with other Fraunhofer Institutes on a new generation of thermal switches based on switchable heat pipes. A heat pipe is comprised of a metal tube, in which a fluid is held in both its gas and liquid phase. When a heat source is placed on the hot side of the heat pipe, the temperature rises, causing the fluid to evaporate. Then, condensation occurs on the cold side of the tube, where the heat sink is located. Thus, heat transfer in a heat pipe takes places by transporting latent heat. This method

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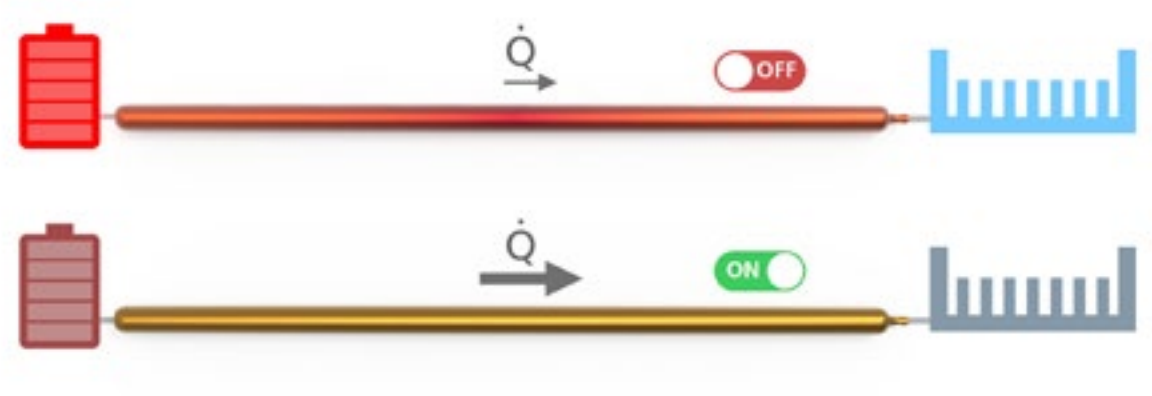

of heat transfer is very effective and provides heat pipes with a very high thermal conductivity. For this reason, heat pipes are generally well suited as the basis for thermal switches.

Hydrophilic sorbents

Assembling a heat pipe thermal switch requires hydrophilic sorbents with temperature-dependent regulating effects to be put into the heat pipe. The sorbents can take on hydrophilic or hydrophobic properties. Switching between these properties occurs at defined transition temperatures, which can be adjusted by varying the composition of the sorbent. In its hydrophilic state, the sorbent absorbs the liquid, which is then no longer available for the evaporation and condensation processes. This stops the heat transfer process, cutting off heat transport more or less completely ("off" position). Above the transition temperature, the absorbed water is released, latent heat transfer can continue through evaporation and condensation processes, and the thermal switch is turned back to the "on" position. A patent has been registered for the thermal switch design described here.

Reduced temperature control requirements for many applications

Switchable heat pipes can be used for a variety of purposes. For example, battery systems, fuel cells and other systems function best at a certain "optimal temperature." If the systems' temperatures are not controlled, their capacity, performance and service life are diminished. Using a switchable heat pipe, temperature control requirements can be substantially reduced. Until the desired operating temperature is reached, the switchable heat pipes transfer almost no heat. If a certain operating temperature is exceeded, the "on" position is activated and excess heat is effectively dissipated. This all takes place automatically, without the need for external intervention or complex sensor technology and control engineering. The switchable heat pipes are therefore suited as "thermal emergency switches", which can dissipate heat if a critical temperature is exceeded.

This solution for heat pipe-based thermal switches can be adapted to many fields of application. Fraunhofer IPM is currently talking to businesses about developing initial system demonstrators. The sectors being covered are electromobility, stationary energy storage (batteries) and aerospace.

Learn more about our research on switchable heat pipes.

Switchable heat pipes are compact and do not require any moving parts. They are easy to integrate and guarantee a very high heat transport capacity.

"We're researching switchable heat pipes with a view to making thermal switches more efficient and cost-effective."

Dr. Markus Winkler, Project Manager