Cool BatMan: Battery Thermal Management System Based on High Power Density Digital Microfluidic Magnetocaloric Cooling

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Li-ion batteries are key to transitioning away from the fossil fuels dependence in the next decade. A major bottleneck in Li-ion's efficient and reliable operation is their narrow temperature range where they operate at full efficiency without major degradation. There are two key aspects of battery thermal management system (BTMS); high efficiency and compactness. The majority of BTMSs are based on vapor-compression technology. Due to utilization of environmentally harmful refrigerants and moderate efficiency there is a need for more efficient cooling technologies. One showing such potential is magnetocaloric (MC) cooling.

State-of-the-art devices use Active Magnetic Regeneration, which is efficient at low frequencies (≤5 Hz) but requires large amounts of magnetocaloric and magnetic materials, also increasing costs. Recent research focuses on high-frequency operation to boost power density, enabling miniaturization and material reduction. Two key challenges are: (1) developing fast, efficient alternating magnetic field sources and (2) advancing thermal management via thermal control devices, including thermal switches.

Microfluidics, key to lab-on-chip devices, offers potential thermal switch mechanisms. While most systems use continuous liquid flow, interest has grown in discrete droplet manipulation via surface tension effects. One approach, ElectroWetting On Dielectric (EWOD), controls liquid wettability on a dielectric surface using an electric potential. Its similarity to digital microelectronics has coined the term "digital microfluidics."

In this talk we will present a new concept of magnetocaloric device which couples magnetocaloric effect and EWOD droplet actuation as thermal switch mechanism. We will show different potential designs of such a device and their operation. Furthermore, the materials and its properties, which constitute the whole device will be discussed.

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