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Ultrathin Heat Spreader Thermal Management of Lithium-ion Batteries for EV and Energy Storage

Ziqi Jiang[1], Yinchuang Yang[1], Huihe Qiu[1,2]
[1]Department of Mechanical and Aerospace Engineering,
The Hong Kong University of Science and Technology,
Clear Water Bay, Kowloon, Hong Kong SAR, China
zjiangaq@connect.ust.hk; yyangbv@connect.ust.hk; meqiu@ust.hk
[2]Sustainable Energy and Environment Thrust,
The Hong Kong University of Science and Technology (Guangzhou),
Nansha, Guangzhou, China 511453
meqiu@ust.hk

Extended Abstract

Lithium ion (Li-ion) batteries are low cost and have a high energy density and a small volume. Thus, battery packs comprised of multiple Li-ion batteries have become the dominant energy source for electric vehicles (EV) and hybrid electric vehicles (HEV), and have contributed to their current popularity, as has fast-charge technology, which is also used in EVs and HEVs. However, due to the high power requirement of EVs and HEVs under high-speed operating conditions or fast charging conditions, Li-ion battery packs suffer from high temperatures if no appropriate thermal management system is installed, leading to battery performance degradation and even thermal runaway [1]. The energy efficiency, safety, and life of power batteries, such as lithium-ion batteries, are very sensitive to temperature, and the performance and stability of Li-ion batteries are reduced in the abnormal temperature range [2]. The temperature change of batteries is usually inevitable because they are affected by environmental conditions and release heat by a series of chemical reactions during charging and discharging. Therefore, it is essential to develop a smart thermal management system that maintains the proper temperature range for power batteries. In this talk, key technologies for a smart thermal management system of power batteries for electric vehicles and energy storage system will be presented. The key technologies are based on our recent findings that utilize multiscale micro/nanostructured surfaces for integrated wicks [3]. These surfaces manipulate the nucleation site density that controls the heat transfer coefficient and critical heat flux for the evaporator of a heat spreader [4, 5]. The multiscale micro/nanostructured wick design and micro/nano multiscale structure fabrication techniques are crucial for controlling the capillary flow and evaporation that improve the effective thermal conductivity of the thermal management system for power batteries. We presented a novel technique for the thermal management of power batteries utilizing ultrathin heat spreaders. Temperature significantly affects the energy efficiency, safety, life, and performance of a lithium-ion battery pack in electric vehicles (EVs). Therefore, controlling the temperature of the battery pack within a certain range has become a challenge in the development of EVs, especially in fast charging with high charge rates (C-rates). An ultrathin thermal ground plane-based battery thermal management system was developed, which utilized 0.4 mm thick ultrathin thermal ground planes and cooling fans as a heat sink. The thermal performance of the novel battery thermal management system was experimentally investigated at 2.2 C to 4 C FC regimes under environmental temperatures from 10 °C to 50 °C. The battery thermal management system was able to maintain a mean surface temperature of 55Ah lithium iron phosphate (LiFeO_4, LFP) batteries below 42.7 °C even at a 4 C charge rate and achieve good surface temperature uniformity in all cases. At an ambient temperature as high as 50 °C, the battery thermal management system can still maintain the mean battery surface temperature under 57.3 °C. The temperature rise, temperature uniformity, and thermal resistance gained improvements of up to 23.3%, 28.4%, and 62.6%, respectively, compared to a battery thermal management system with the same dimensions as copper heat spreaders. The effects of different pores densities of the mesh in the ultrathin thermal ground plane were also studied. The battery thermal management system showed brilliant performance in controlling the temperature of the battery pack, which was capable of being a viable solution for high-power battery thermal management in EVs.

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