In-situ diagnosis of Li-ion battery state via swelling behavior using 3D printed piezoresistive sponge sensor

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As the commercialization of electric vehicle technology accelerates, the importance of lithium-ion battery, a core component of electric vehicles, is gradually emphasized. However, lithium-ion batteries have difficulties in state recognition, and also have safety risks of thermal runaway that causes fire and explosion due to its electrochemical instability. Most of the electric vehicles use battery management system for state diagnosis and hazard prevention via current, voltage, and temperature sensing, but there are still lack of direct risk detection and state monitoring under complicated environments. Also, it is hard to apply additional sensor in electric vehicle battery module, owing to the compact packaging for high energy density. Herein, we developed a low-cost piezoresistive sensor based in-situ diagnosis system of large capacity lithium-ion battery through swelling behavior monitoring. A 3D printed, module-applicable, and high-performance sponge sensor was developed, and utilized for battery swelling detection. Due to the swelling behavior of the battery that occurs under various cycling, aging, and hazardous conditions, it was able to diagnosis the battery state with developed sensor system. Various battery cycling tests were conducted with applied swelling sensor to demonstrate the battery monitoring performance and analyze the correlation between battery state and swelling pressure. We propose that by integrating our battery diagnosis system with battery management system, the reliability and safety of electric vehicle battery could be enhanced.