Mechanical and Civil Engineering Thesis Defense

Friday, February 5, 2016

10:00 a.m. in 306 Firestone

"Topology optimization of silicon anode structures for lithium-ion battery applications"

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Abstract

This thesis presents a topology optimization methodology for the systematic design of optimal multifunctional silicon anode structures in lithium-ion batteries. In order to develop next generation high performance lithium-ion batteries, key design challenges relating to the silicon anode structure must be addressed, namely the lithiation-induced mechanical degradation and the low intrinsic electrical conductivity of silicon. As such, this work considers two design objectives of minimum compliance under design dependent volume expansion, and maximum electrical conduction through the structure, both of which are subject to a constraint on material volume. Density-based topology optimization methods are employed in conjunction with regularization techniques, a continuation scheme, and mathematical programming methods. The objectives are first considered individually, during which the iteration history, mesh independence, and influence of prescribed volume fraction and minimum length scale are investigated. The methodology is subsequently extended to a bi-objective formulation to simultaneously address both the compliance and conduction design criteria. A weighting method is used to derive the Pareto fronts, which demonstrate a clear trade-off between the competing design objectives. Furthermore, a systematic parameter study is undertaken to determine the influence of the prescribed volume fraction and minimum length scale on the optimal combined topologies. The developments presented in this work provide a foundation for the informed design and development of silicon anode structures for high performance lithium-ion batteries.