Shape sensitivity for thermal design problem based on the Boltzmann Transport Equation

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The thermal design is essential for the development of many devices especially miniaturized electric devices. Controlling heat in the system is an important point for three aspects, that is, performance, safety and reliability. First one is that high temperature leads to decrease the operating speed. Second is that heating a device makes the device malfunction and increase the failure frequency, finally decrease the lifespan of device. Third one is that excess heating a device result in emitting smoke and firing the device. Conventional thermal design methods only focused on the macro structures. On the other hand, in recent years, many researchers have been interested in developing new material properties with manipulating nano structures. Caylor et al. succeeded to increase the energy-conversion efficiency by introducing super structures [1]. Yu et al. propose to decrease the thermal conductivity by formatting the material which has the periodic holes [2]. Above previous researches succeeded to propose innovative materials or material properties. However, their approaches depend on heuristic methods and there are few reports which dealt with the design criteria. On the other hand, our group has proposed the optimization methods or design sensitivities as design criteria [3], [4]. In this paper, we propose a shape derivative for a thermal design problem based on the Boltzmann Transport Equation. Utilizing this design sensitivity, we can design an electric device with considering nano-effects such as temperature discontinuity or ballistic conduction.

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