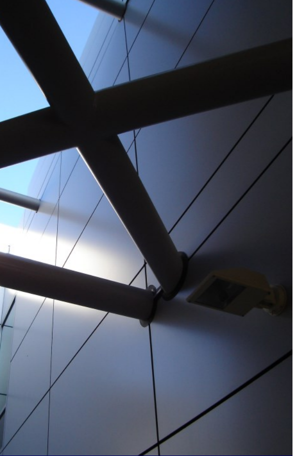

The Department of Mechanical Engineering presents:

The Ph.D. Dissertation Defense of

Andisheh Tavakoli

Monday, June 21, 2021,
11am Pacific time

Design and Optimization of a Composite Heat Spreader to Improve the Thermal Management of Three-Dimensional Integrated Circuits

Doctor of Philosophy, Mechanical Engineering
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Dr. Kambiz Vafai, Chairperson

The present study documents the optimal distribution of a limited amount of high thermal conductivity material to enhance the heat removal of 3D integrated circuits, ICs, numerically. The structure of the heat spreader is designed as a composite of high thermal conductivity (Boron Arsenide) and moderate thermal conductivity (copper) materials. The volume ratio of high conductivity inserts to the total volume of the spreader is fixed. For the configuration of the inserts two categories are considered, namely ring type and blade type. For the former, various patterns of the single and double ring inserts are studied; while for the latter, three main configurations including radial, one level of pairing, and two levels of pairing are examined. To examine the impact of adding high conductivity inserts on the cooling performance of the heat spreader, a detailed analysis is performed to find the optimal geometry for each category. An approach is implemented to find the structures corresponding to the lowest maximum temperature of the 3D IC while the ratio of the Boron Arsenide volume to the whole heat spreader volume is fixed. Four different boundary conditions are examined to seek their impact on the optimal configuration of the inserts. For the double ring insert layout, the optimal distribution of the high-conductivity material between the inner and outer rings is found. The results show that for the optimal conditions, the maximum temperature of the 3D IC is reduced up to 10%. For the blade inserts, the results show that for the constant temperature, variable temperature, and convection heat transfer boundary conditions at optimal conditions, the maximum temperature of the whole structure can be reduced to 13.7, 11.9, and 13.9%, respectively; while the size of the heat sink, and heat spreader is mitigated by 200%.

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