Thermal Modeling and Analysis for Optoelectronic Packaging

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Microelectronics Heat Transfer Laboratory

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Microelectronics Heat Transfer Lab

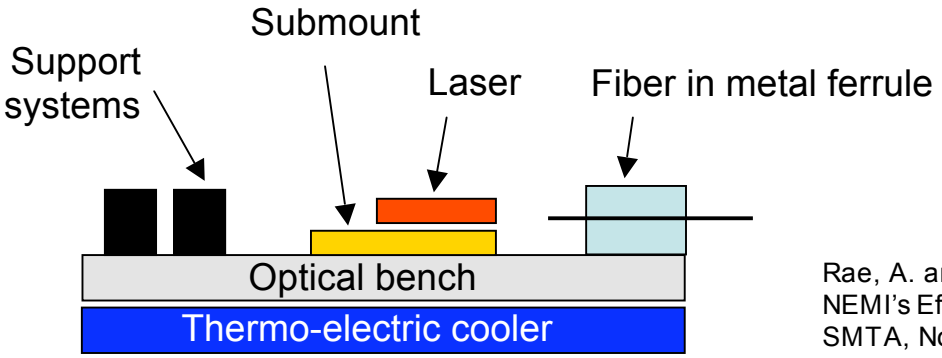
- Established in 1984 within the Department of Mechanical Engineering
- Research and development related to heat transfer and other thermodynamic phenomena
- Fully funded through industrial and governmental grants and contracts
- Staff includes:
  - 2 faculty members, 1 retired faculty member
  - 7 graduate students
  - 2 post doctoral fellows, 1 research engineer

Collaborative Research Partners

- Telecommunications / Networking / Electronics Cooling
  - Nortel Networks
  - Alcatel
  - IBM
  - Sun Microsystems
  - Celestica
  - Motorola
  - Seiko Epson
  - Nikon
  - ATS
  - R-Theta
  - Raytheon
- Industrial / Automotive
  - Ford
  - W.E.T. Automotive Systems
  - Siemens
  - Dupont
- Research Institutes
  - NRC
  - Oakridge National Laboratories
  - AECL
- Granting Agencies
  - NSERC
  - MMO
  - CMAP

Thermal Issues in Optoelectronic Packaging

- Typical "butterfly" (Level 1) package
  - Precise temperature control at laser required, $\pm 0.5\,^{\circ}C$
  - Spreading resistance in laser submount and optical bench (substrate)
  - Thermal contact resistance at submount, TEC joints
  - TEC efficiency
  - Heat sink optimization for cooling of TEC



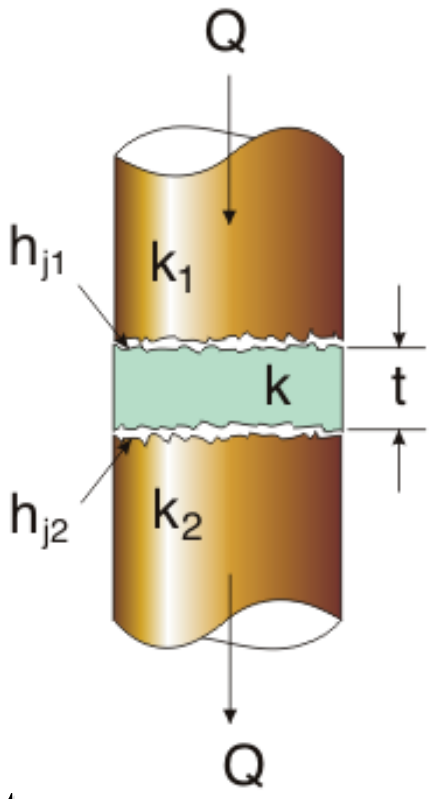
Rae, A. and Gedney, R.
NEMI's Effort to Make Optoelectronics Manufacturing Mainstream
SMTA, Nov. 13 – 15, 2001

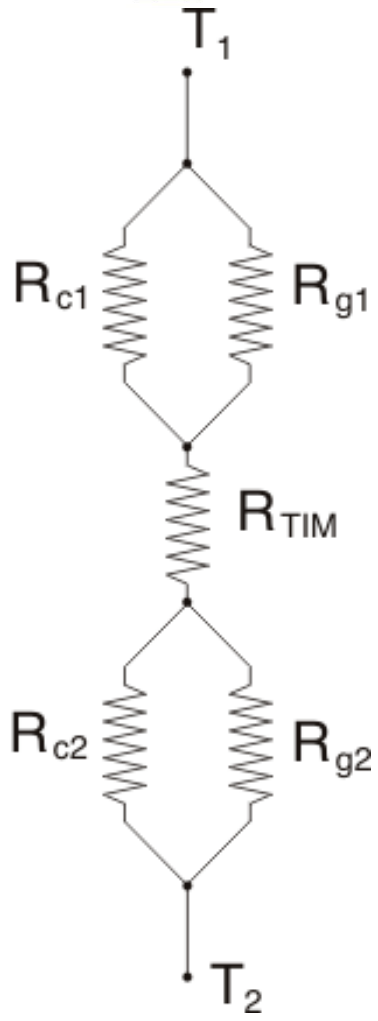
Research Areas and Capabilities

- Thermal contact resistance
  - Thermal interface materials, thermal compounds
  - Phase change materials
  - Metallic layers
- Thermal spreading resistance
  - Analytical modeling
  - Thermal conductivity measurements, materials characterization
- Heat sink optimization
  - Forced convection air cooled heat sinks
  - Liquid cooled cold plates
  - Heat pipe enhanced heat sinks

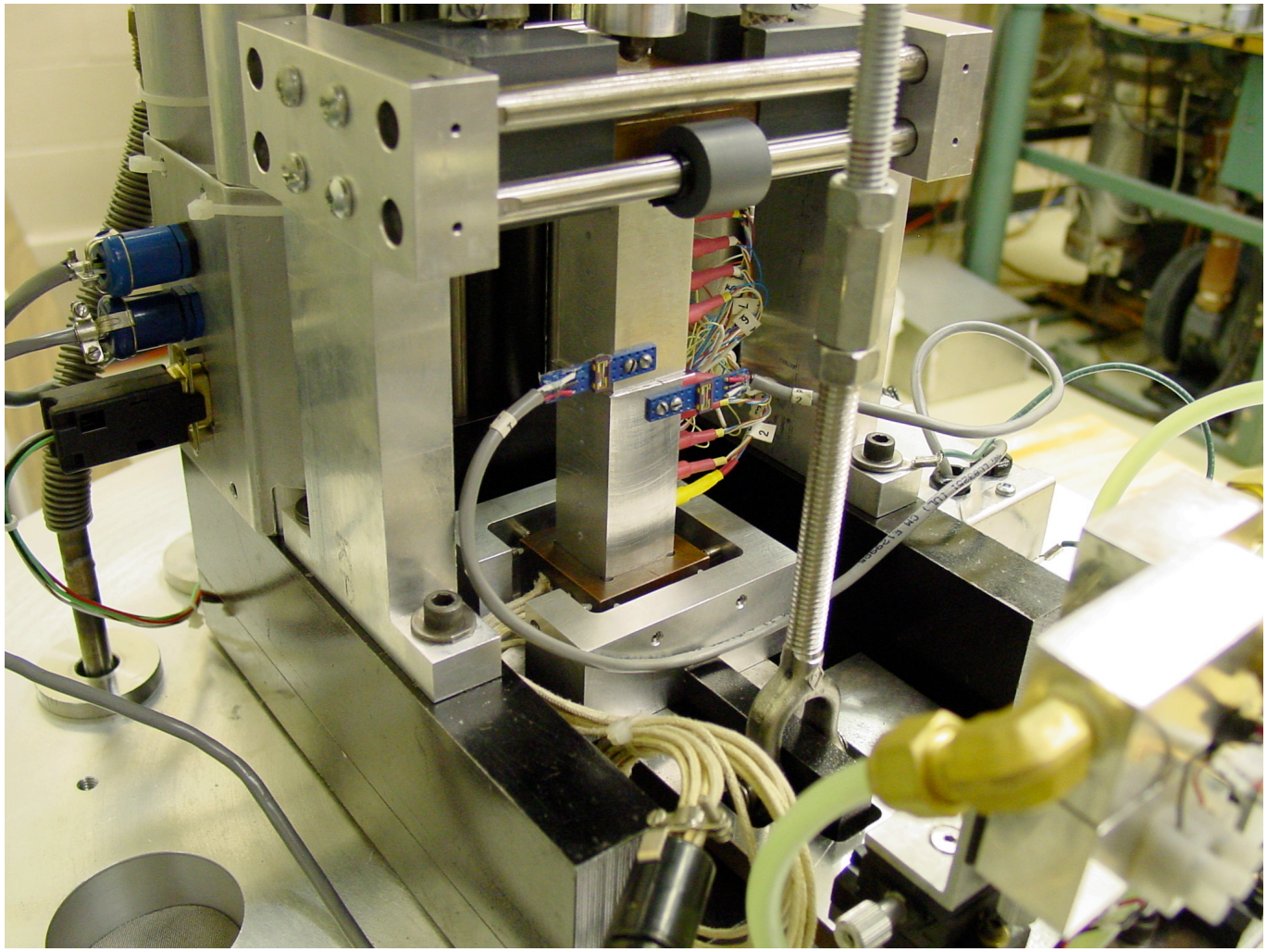
Thermal Contact Resistance

- Experimental measurements
  - Thermal joint resistance
  - In-situ thickness
  - Thermal conductivity
- Thermal interface materials
  - Polymeric layers
  - Thermal greases, compounds
  - Phase change materials
  - Metallic foils, solder
- Analytical model development



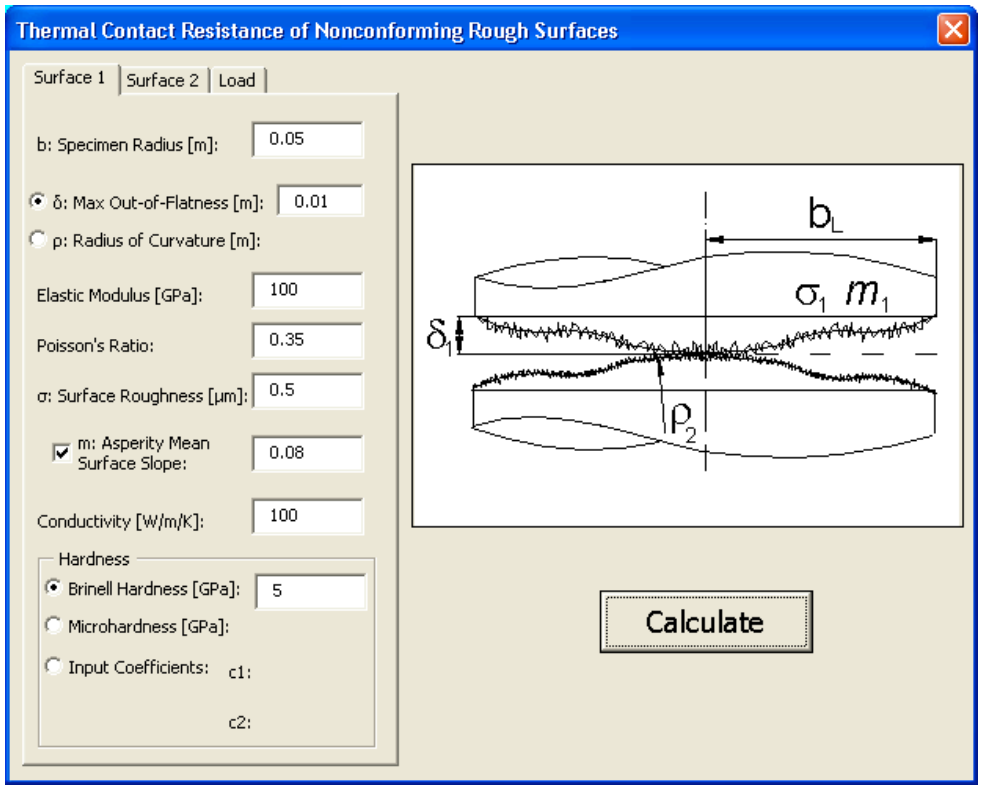


TIM Test Apparatus



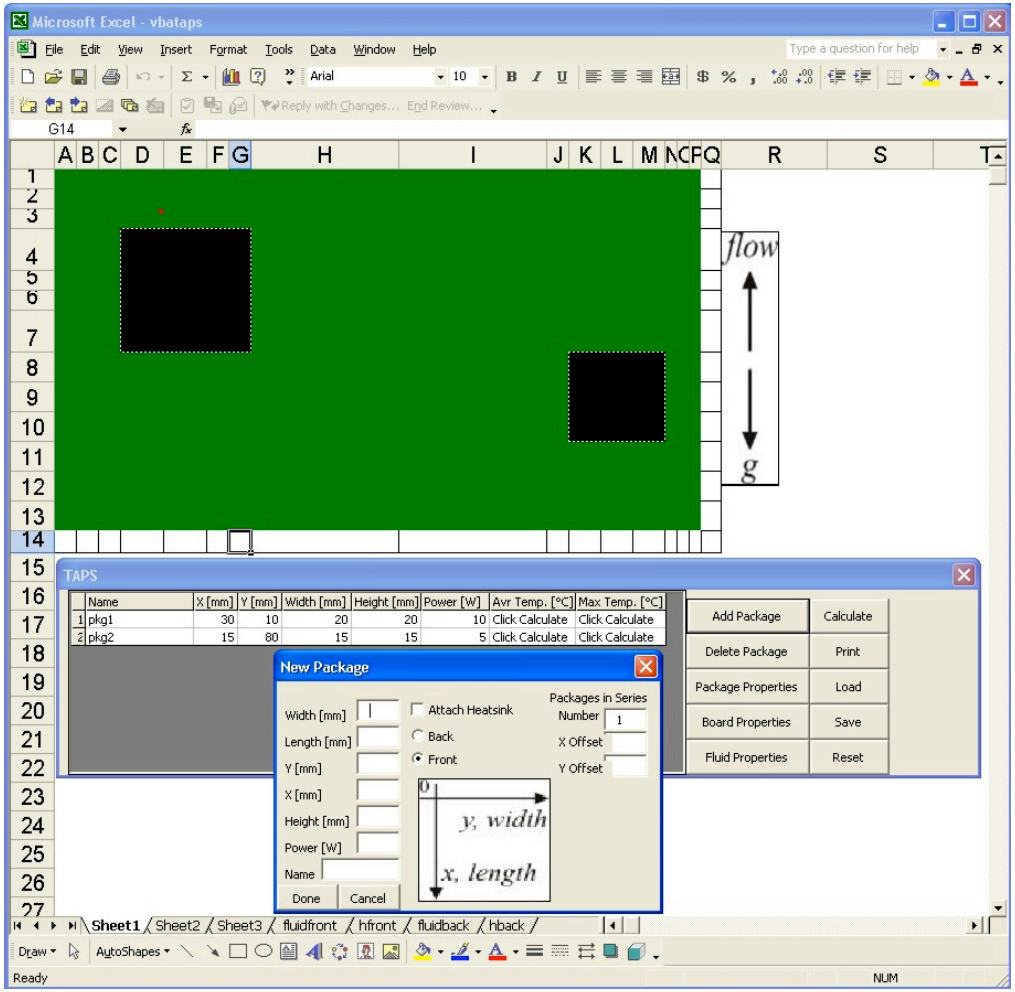
Analytical Model Development

- Models developed from physically-based analysis
- Input variables
  - Geometry
  - Thermal properties
  - Mechanical properties
  - Surface characteristics
- Easy to implement design tools
  - Excel spreadsheets
  - Web-based applications



Spreading Resistance

- Homogeneous, multilayered substrates
- Multiple discrete sources
- Analytical modeling
- Numerical simulation
- Excel spreadsheet design tool



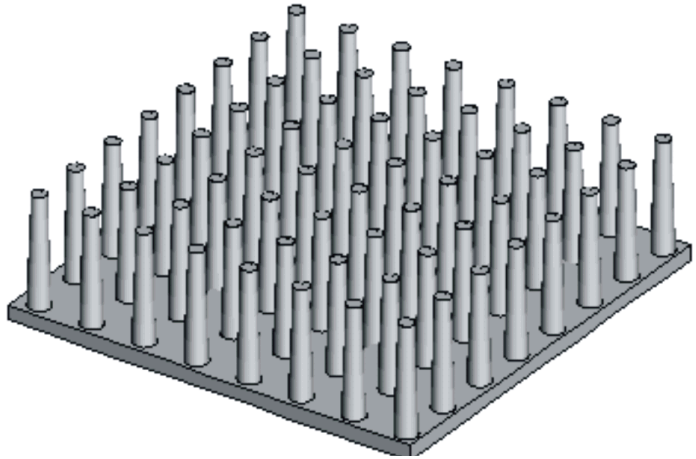
Heat Sinks and Cold Plates

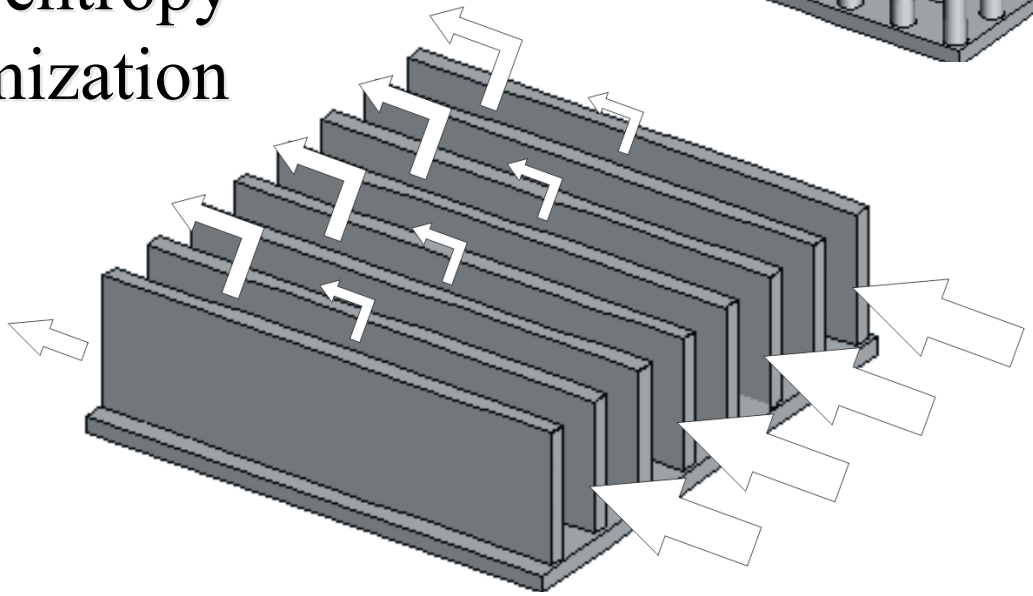
Experimental measurements

- Wind tunnel
- Liquid cooling test apparatus

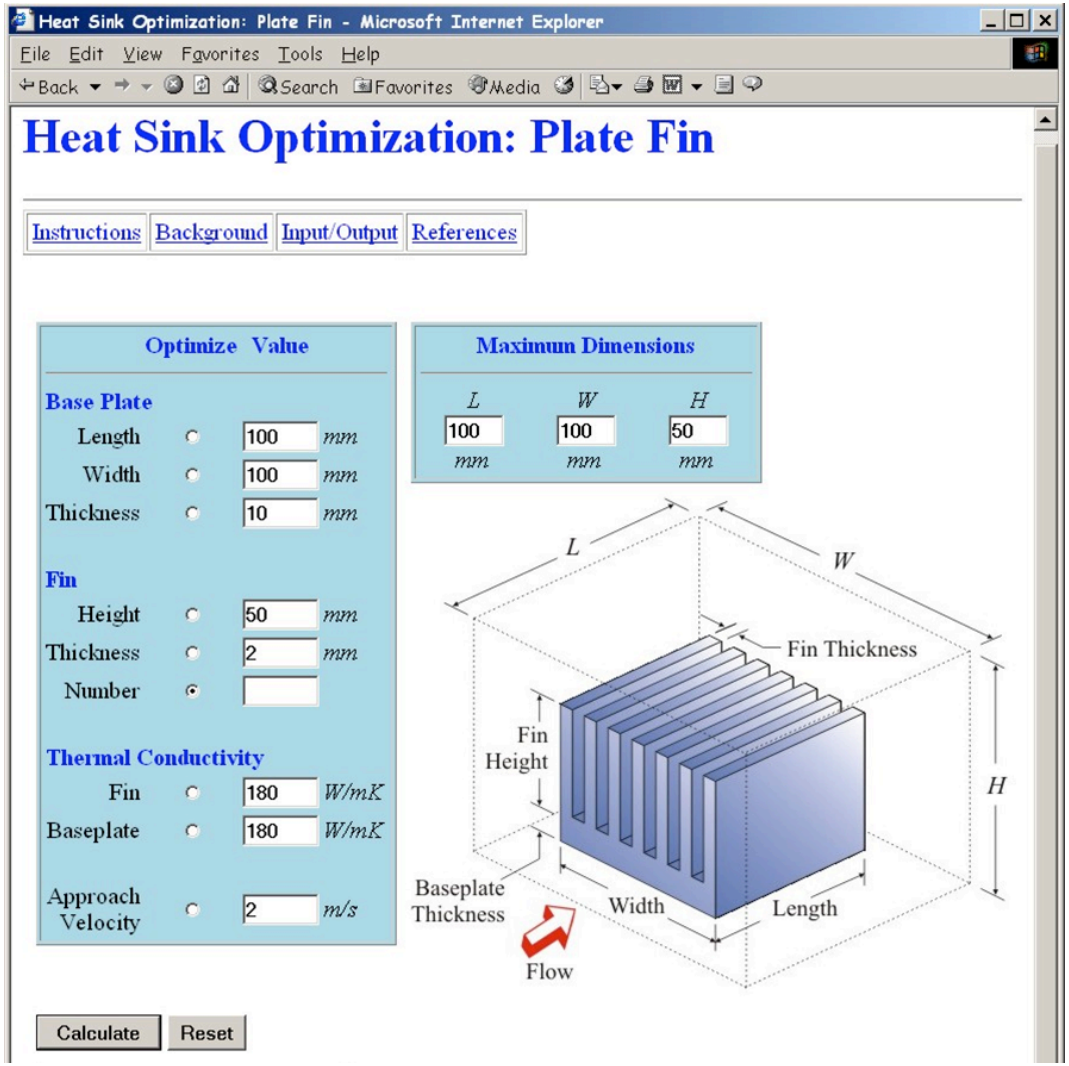
Heat Sink / Cold Plate Optimization

- Air cooled heat sinks
  - Plate, pin fin heat sinks
  - Flow by-pass
  - Spreading resistance
- Optimization by entropy generation minimization (EGM) analysis





Web-based Optimization Tool



Thank you

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