



Department of Mechanical Engineering
Indian Institute of Technology Kanpur
Kanpur 208016
India

Summary of activities at IIT Kanpur during September 2004 to March 2009

Sameer Khandekar

Assistant Professor

Department of Mechanical Engineering

Indian Institute of Technology Kanpur

Tel: 0512-259-7038 Fax: 0512-259-7408

E-mail: samkhan@iitk.ac.in



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In this presentation...

- Brief background information
- Academic achievements
- Laboratory development activities
- Research and developmental activities
- Teaching activities
- Dissemination of results/ Publication record
- Administration



Educational qualifications

1993 • B. E. (Mechanical Engineering)
Government Engineering College, Jabalpur (MP), India.

Worked in industry for
four years; GATE 1998

2000 • M. Tech. (Thermo-fluid Sciences)
Indian Institute of Technology Kanpur, Kanpur, India.

Thesis title: Numerical Modeling of Packed Bed Type Catalytic Converter for Small Two-Stroke Petrol Engines and its Experimental Validation
Sponsored by Indian Oil Corporation Limited (IOC)

2004 • Ph. D.
University of Stuttgart, Stuttgart, Germany, 2004.

Thesis title: Thermo-Hydrodynamics of Closed Loop Pulsating Heat Pipes
Sponsored by Deutsche Forschungsgemeinschaft (DFG)



Industry experience

- Joined the industry after under-graduate education
- Worked for four years from July 1994 - June 1998
- Marine Power Plant Engineer Officer onboard seagoing merchant vessels (Larsen & Toubro Limited, Mumbai and Barber Ship Management, Malaysia)
- Marine Engineering Certification at Naval Workshop/ dry-docks at Mumbai.

The specifications of the two vessels on which sailed are:

- **MV Ganta (Car Carrier)**: Main propulsion marine diesel engine MITSUBISHI SULZER 6RND 68M, 11400 BHP, @150 rpm, with Auxiliary Vertical Boiler and Exhaust Gas Boiler of working pressure = 8 bar, Marine Generator Sets, 2 Nos., YANMAR-6UAL-ST.
- **MV LT Pragati (Bulk Carrier)**: Main propulsion Marine Diesel Engine - MITSUBISHI SULZER 6RTA 58M, 9600 BHP, @116 rpm, with Auxiliary Vertical Boiler and Exhaust Gas Boiler of working pressure = 12 bar, Marine Generator Sets, 2 Nos., YANMAR-6UAL-ST.

GOI Certificate courses completed

Fire fighting at sea, Survival at sea, Advanced engine room simulator,
Eligibility Certificate for Second Engineer Officer.



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Academic achievements

- George Grover Young Scientist Medal from International Heat Pipe Committee, 2007.
- Member of the International Heat Pipe Committee since April 2007.
- Young Scientist Award by Department of Atomic Energy, Government of India, 2005.
- Doctoral dissertation grade 1 on a scale of 4 (Highest grade; “Summa Cum Laude”).
- First position in the M. Tech. Program (FTS), IIT Kanpur, India with CPI = 9.7/10.
- Five university gold medals for various achievements including first position in the under-graduate Mechanical Engineering program of Government Engineering College, Rani Durgavati Vishvavidyalaya, Jabalpur (MP) India.
- National merit scholarship for the entire undergraduate education in India.
- Lions Club Award for the best all around student at intermediate college.



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Present research focus

Experimental heat transfer with a focus on issues related to phase-change phenomena in mini/micro systems

Development of internet based experiments

Key words

Liquid-Vapor Phase Change Phenomena

Heat Pipes/ Pulsating Heat Pipes/ Thermosyphons

Flow and Heat Transfer in Narrow Channels

Dropwise Condensation

Oscillating Taylor bubble flows

Passive cooling techniques

Energy Systems

Nanofluids



Research laboratory development

Clean Air Conditioned Laboratory Space (200 m²)

Major equipment

- High Speed Infrared Thermographic Camera (FIST)
- 200 W Laser micromachining station
- Turbo-molecular / Diffusion vacuum pumps (3)
- Helium leak detector
- 15mW He-Ne Laser, Optical Bench
- Optical microscope
- Air flow facility (wind tunnel)
- Constant temperature baths (4)
- High speed/ Precision NI-DAQ systems (5)
- Color and Monochrome CCD camera (2)
- Digital video/still camera (2)
- Vacuum oven

Fabrication Workshop

- Table Top CNC Machine
- Conventional Lathe Machine
- Milling and Radial Drilling Machine
- Arc/Gas Welding; Brazing station
- Air Compressor

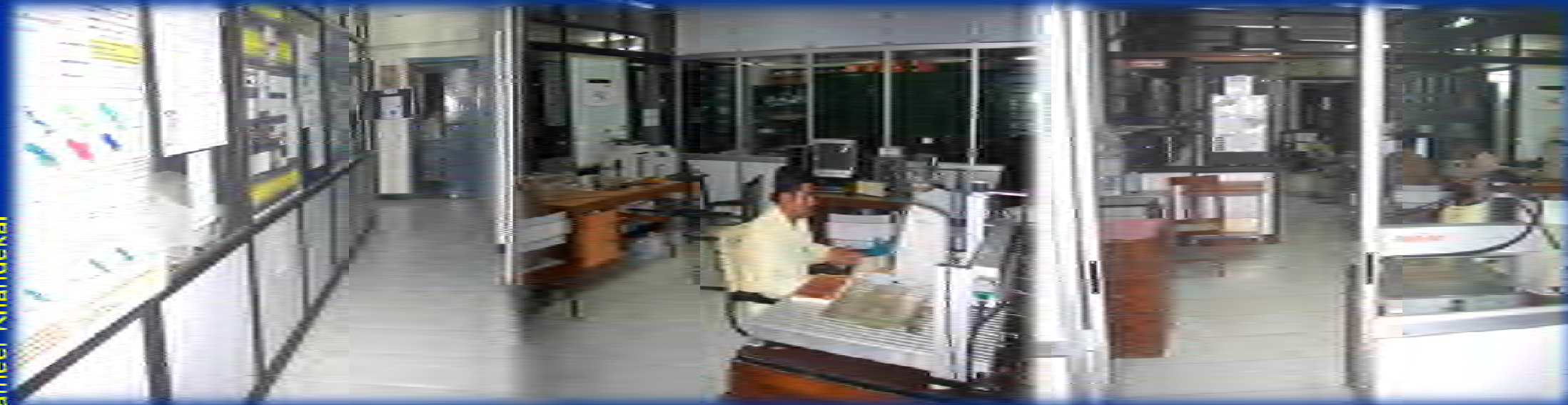
Accessories

- PCs (10); Work Stations (2)
- Fire fighting equipment
- Photo copier, Overhead beamer
- Aquaguard/ Refrigerator
- Online UPS, Voltage Stabilizers

Laboratory photographs (SL – 109)



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Laboratory photographs (Old Boiler House)



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Sponsored research

- Project # 1 (Completed)

Modernization of Refrigeration and Air Conditioning Laboratory (ME) and Research Initiation in Microscale Multi-phase Systems

Indian Institute of Technology Kanpur (Faculty initiation grant)

Budget: INR 10 lacs Time: 1 Year (May 2005-April 2006)

PRINCIPAL INVESTIGATOR

- Project # 2 (Completed)

Development of Pulsating Heat Pipe Based Space Radiators

Indian Space Research Organization

Budget: INR 15 lacs Time: 3 Years (May 2005-April 2008)

PRINCIPAL INVESTIGATOR

- Project # 3 (Completed)

Drop-wise Condensation on an Inclined Surface Exposed to a Vapor Flux (with Dr. K. Muralidhar)

Board of Research in Nuclear Sciences

Budget: INR 40 lacs Time: 4 Years (May 2005-April 2009)

CO-INVESTIGATOR

- Project # 4 (Completed)

Design and Development of Novel Pulsating Heat Pipe Based Compact Heat Exchangers

Department of Atomic Energy Young Scientist Award

Board of Research in Nuclear Sciences

Budget: INR 10 lacs Time: 3 Years (April 2006-March 2009)

PRINCIPAL INVESTIGATOR



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Sponsored research

- Project # 5 (Ongoing)
(with Dr. D. Kunzru, Dr. S. Panda and Dr. P. K. Panigrahi)
Micro-devices for Process Applications
Department of Science and Technology
Budget: INR 500 lacs Time: 5 Years (April 2006-March 2011)

CO-INVESTIGATOR

- Project # 7 (Ongoing)
Pulsating Heat Pipe Based Compact Heat Exchangers for Passive Heat Removal
Department of Atomic Energy
Budget: INR 80 lacs Time: 4 Years (January 2009-December 2012)

PRINCIPAL INVESTIGATOR

- Project # 8 (Just approved!)
Development of Internet based Heat Transfer Laboratory
Ministry of Human Resource Development
Budget: INR 50 lacs Time: 1 Year (April 2009-March 2010)

PRINCIPAL INVESTIGATOR

- Project # 9 (Submitted)
Thermo-hydrodynamics of Oscillating Taylor Bubble Flows
INDO-FRENCH Center for Promotion of Advanced Scientific Research (CEFIPRA)
Budget: INR 80 lacs Time: 3 Years (May 2009-April 2012)

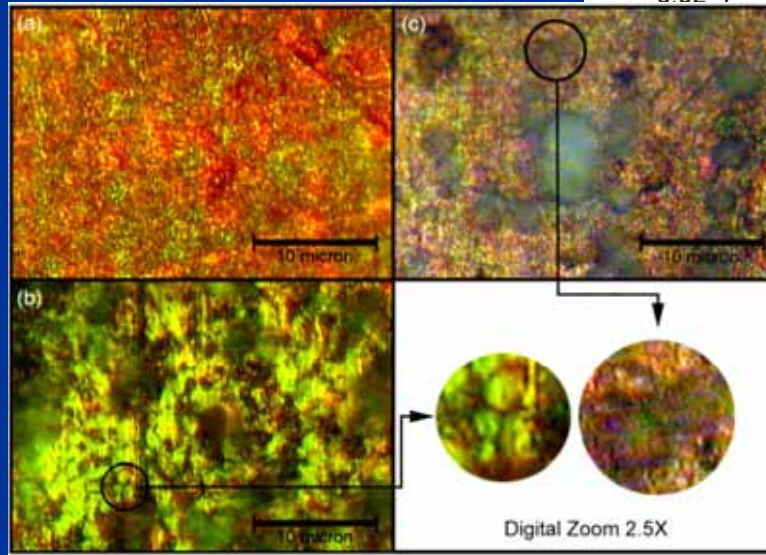
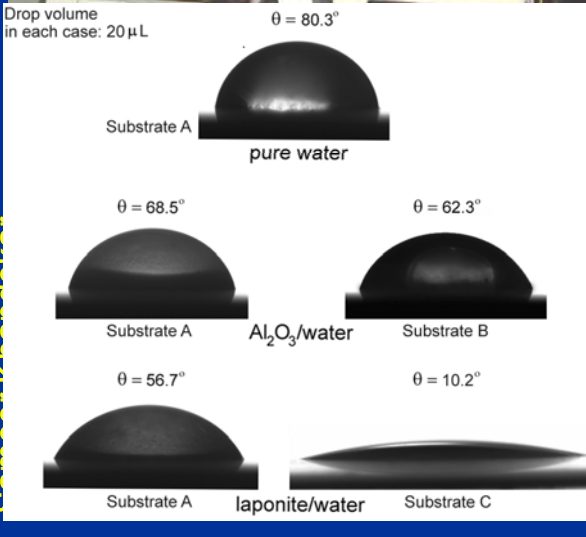
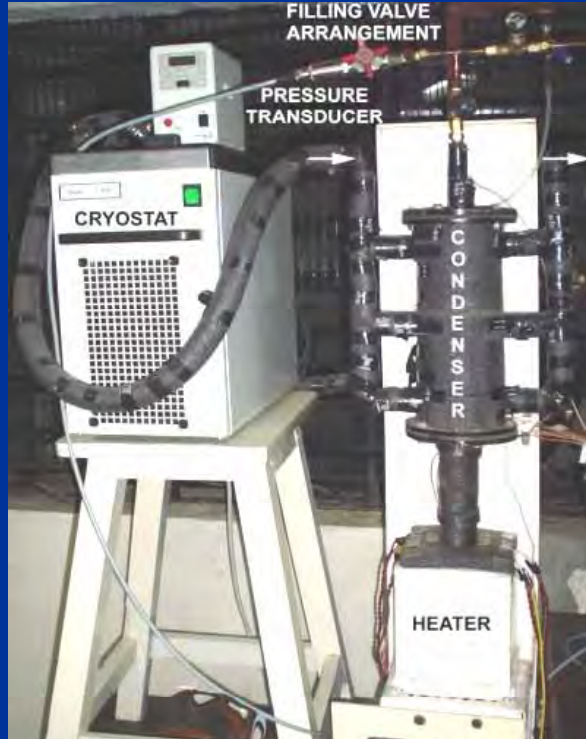
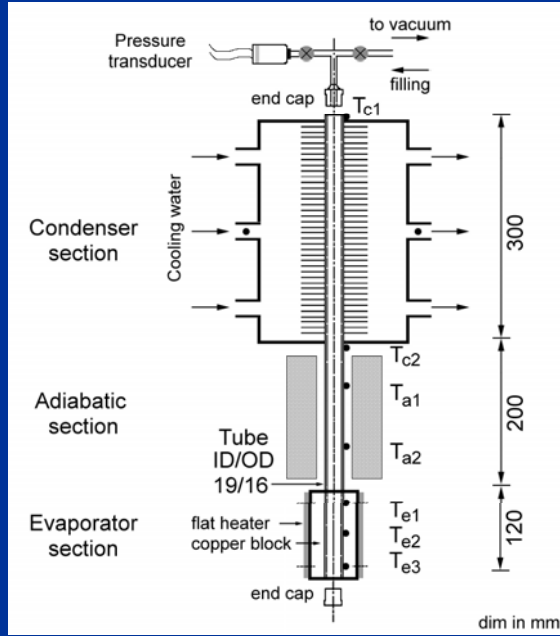
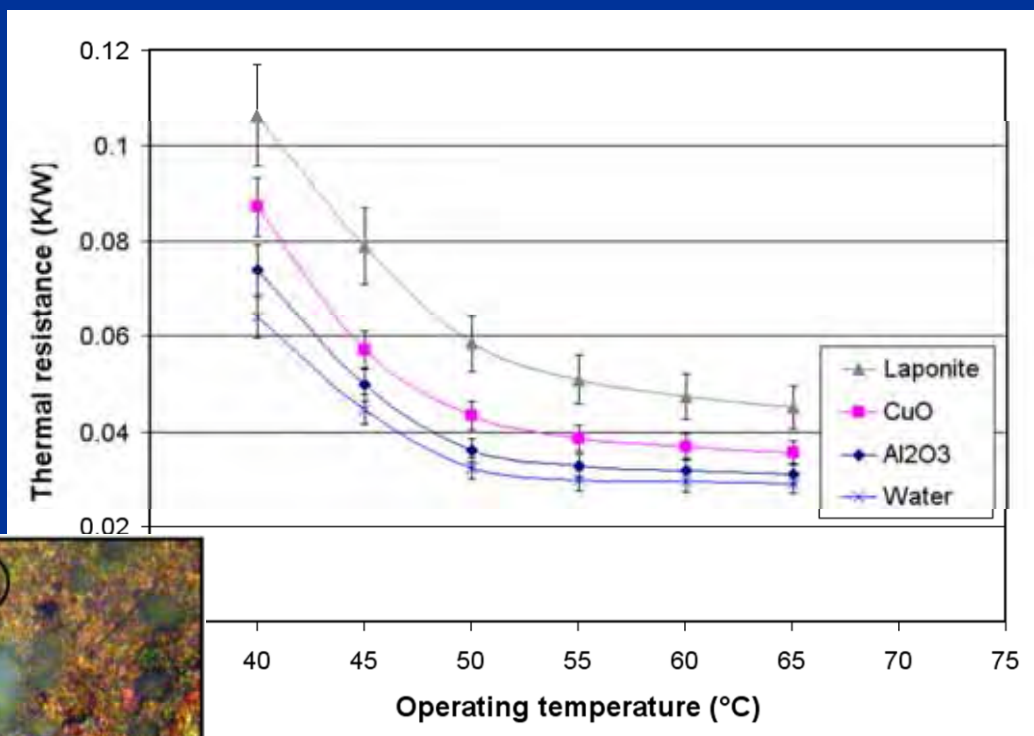
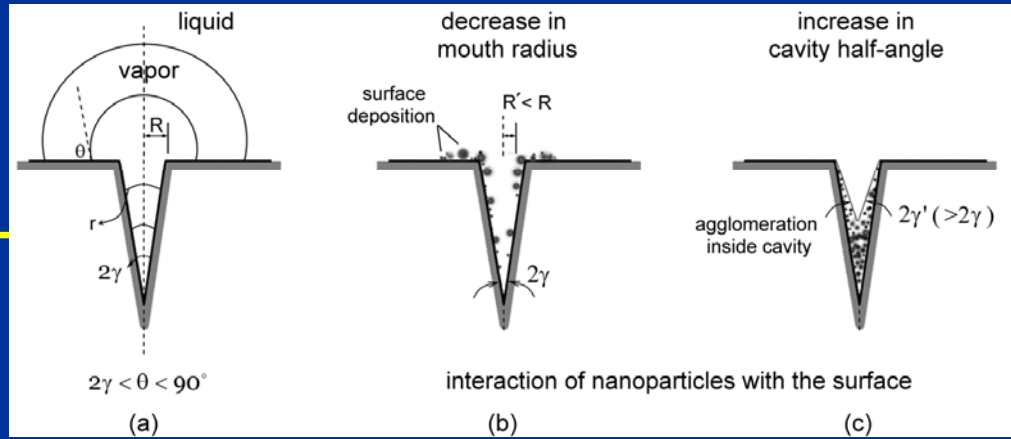
PRINCIPAL INVESTIGATOR



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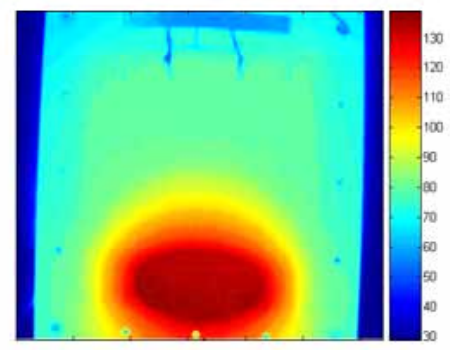
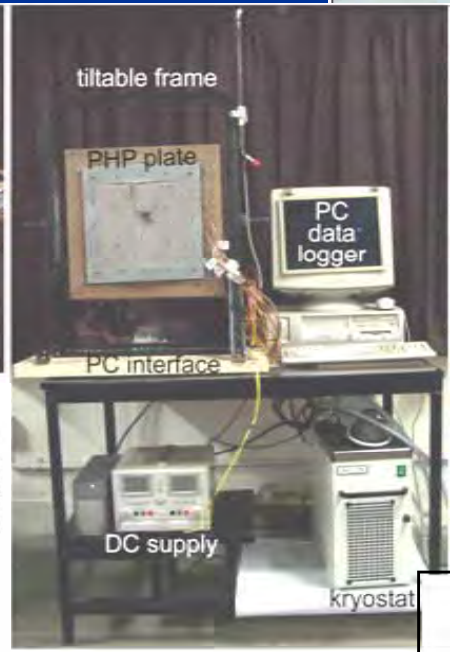
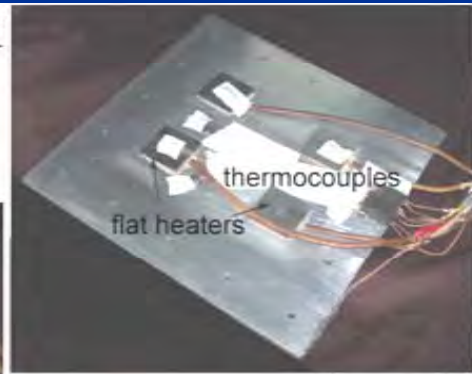
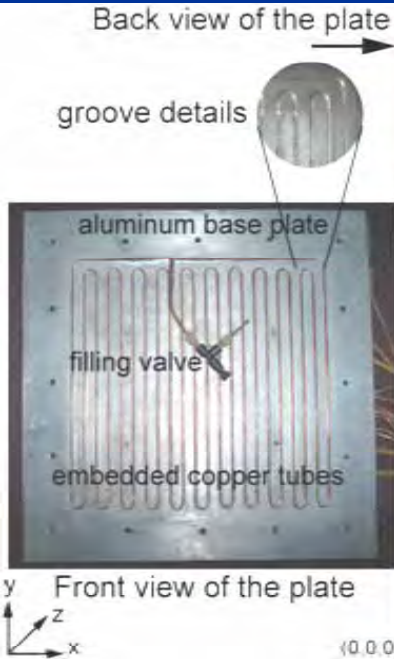
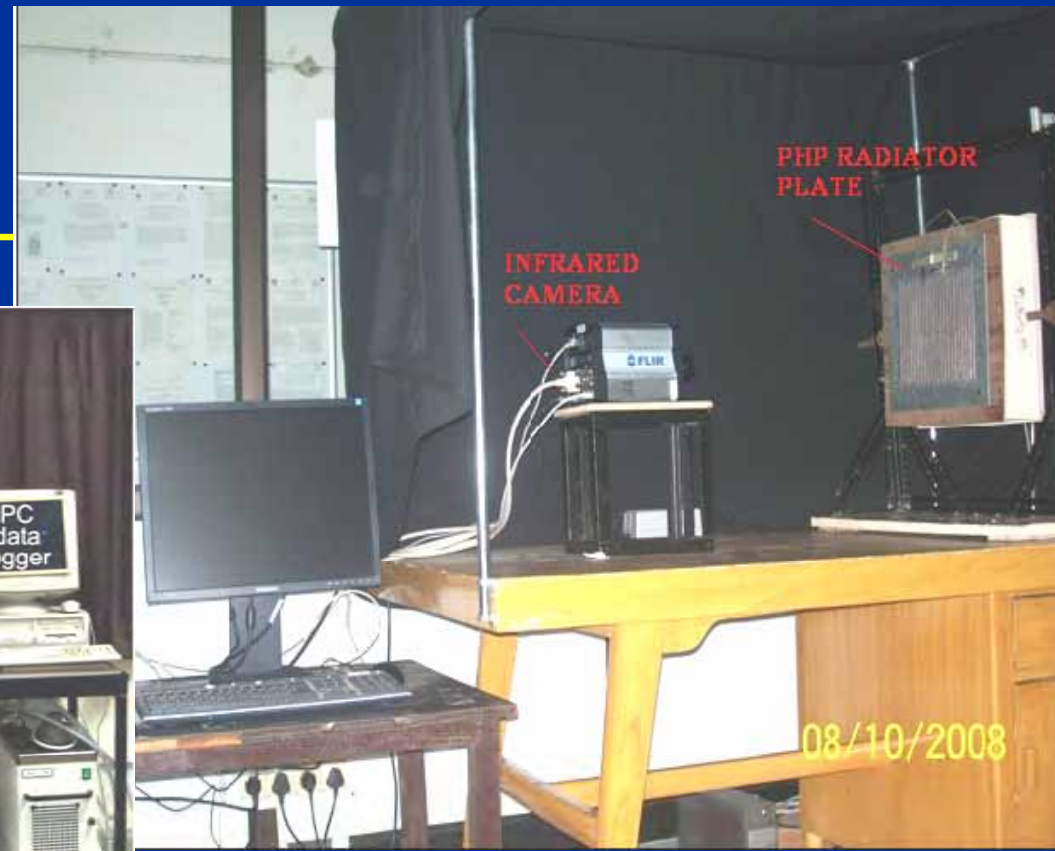
Research Update/Overview

Nanofluids under pool boiling

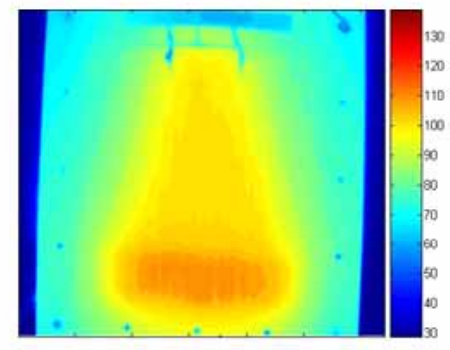


Most downloaded paper for nearly a year

Pulsating heat pipes as radiators



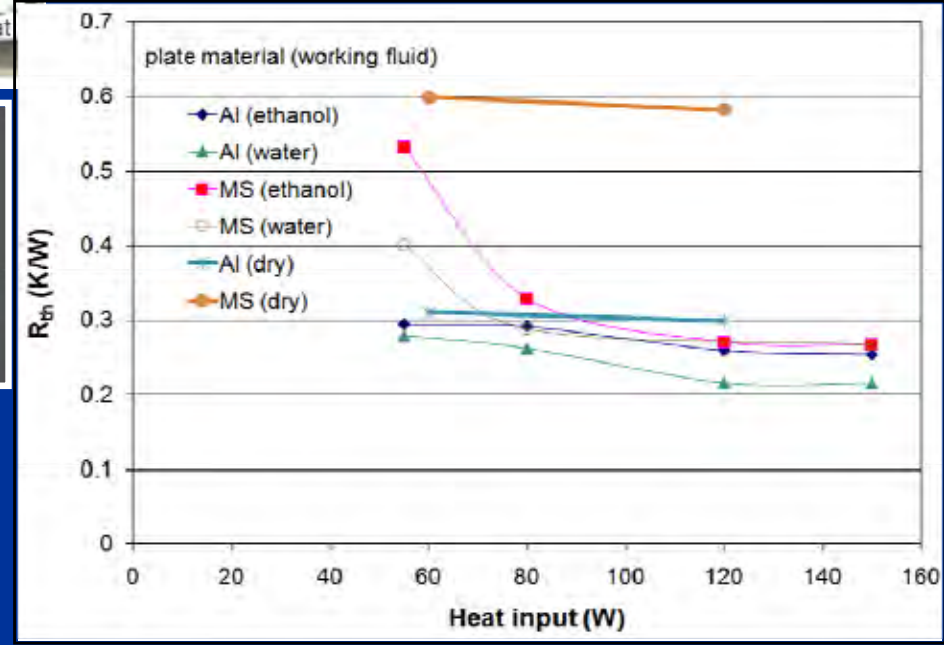
(a)



(b)



Infrared Thermography



Proof of concept done for ISRO

Power Electronics Cooling Pulsating Heat Pipes

PHP details

Base area : 100 mm X 100 mm
 Height : 92 mm
 Rows : 8
 Columns : 14
 Turns : 112 on each side
 Pipe OD : 3.0 mm
 Pipe ID : 2.0 mm



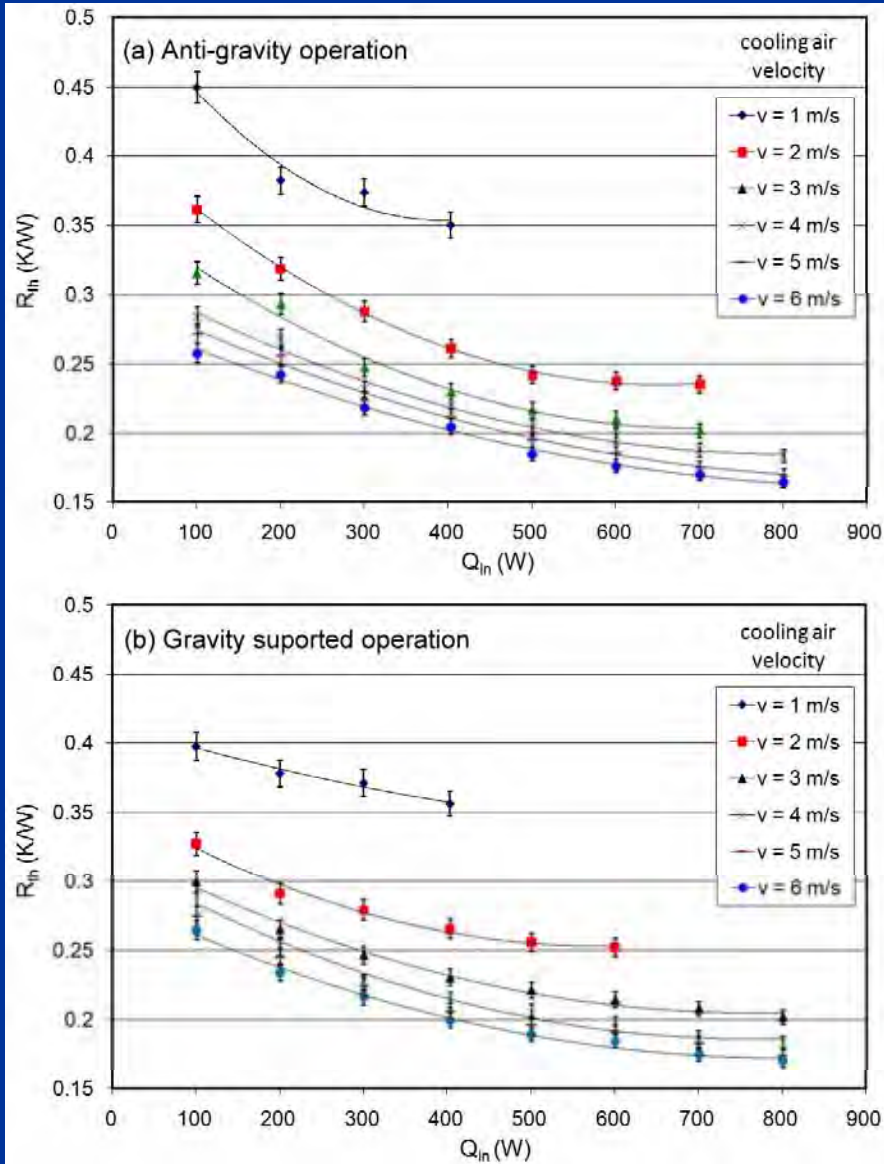
Photograph of the PHP

Air flow facility details

Section : Rectangular
 height (H) - 135 mm
 width (W) - 156 mm
 length (L) - 2000 mm

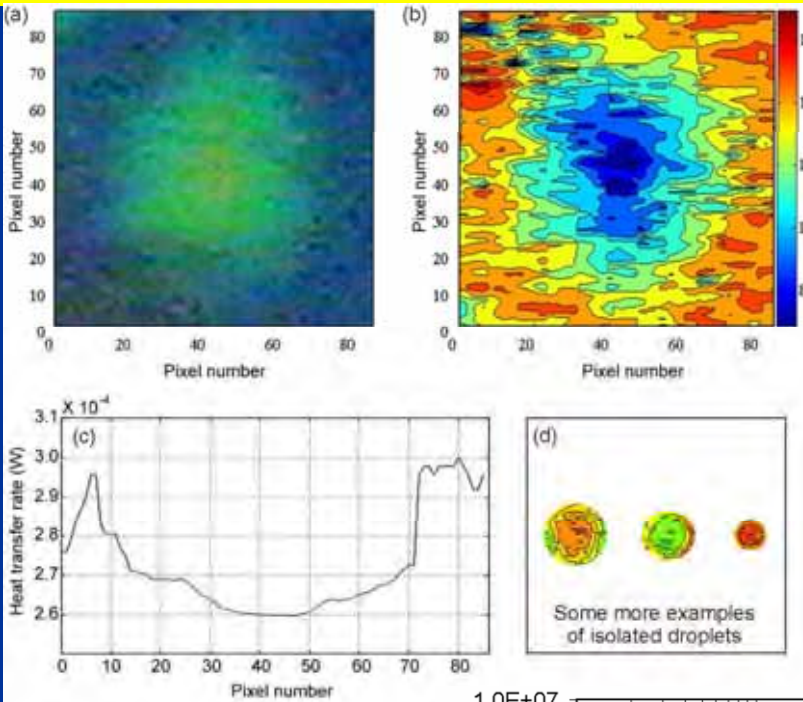
Air velocity : 0.2 - 6 m/s

Fully developed turbulent flow

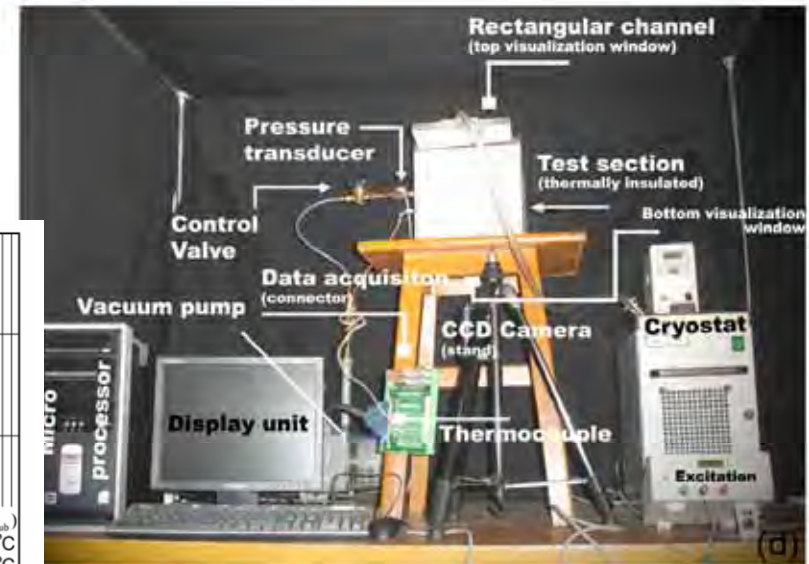
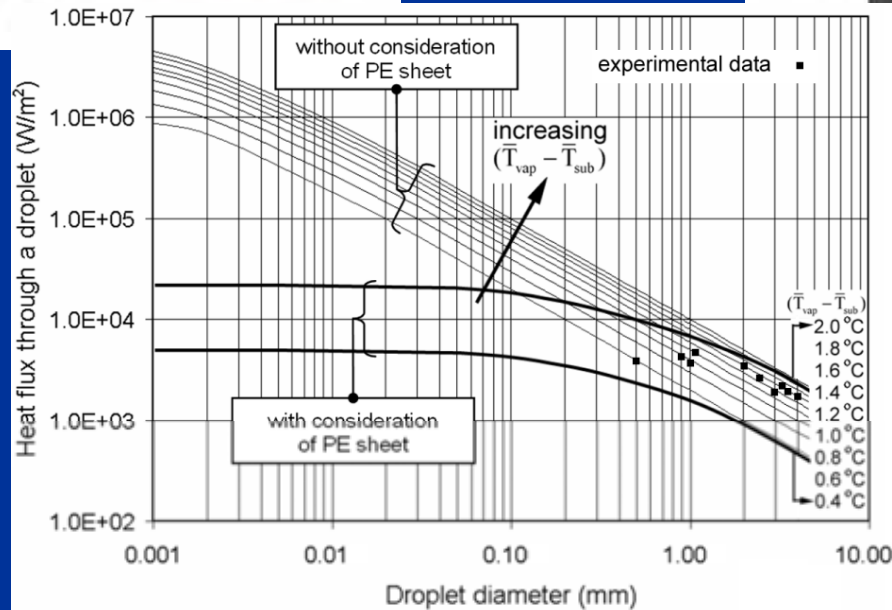
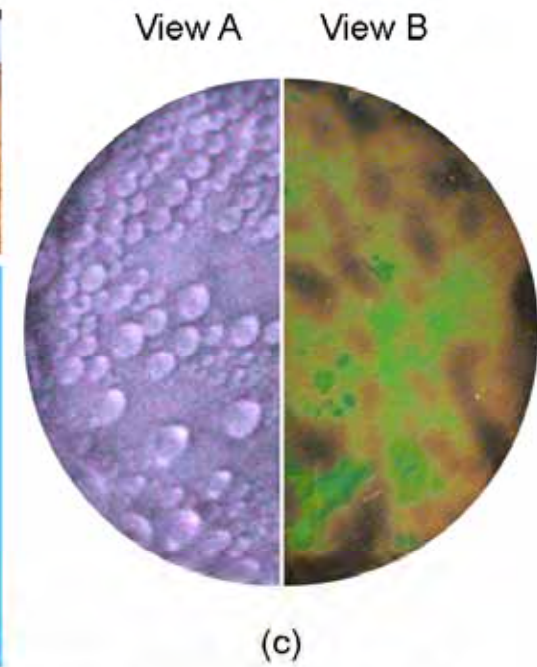
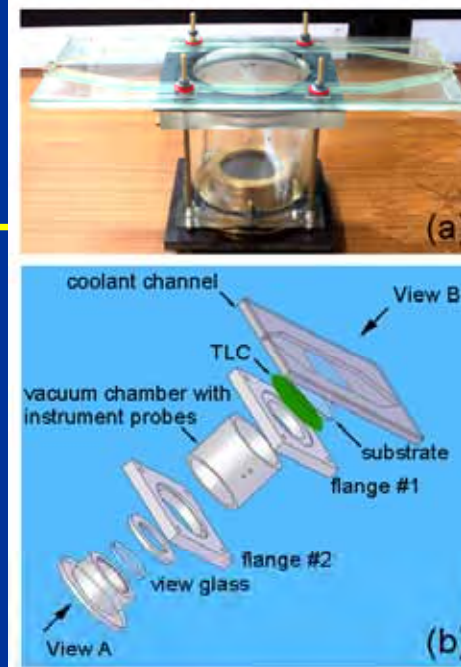


Experimental PHP setup in the flow facility

Dropwise condensation Liquid Crystal Thermography

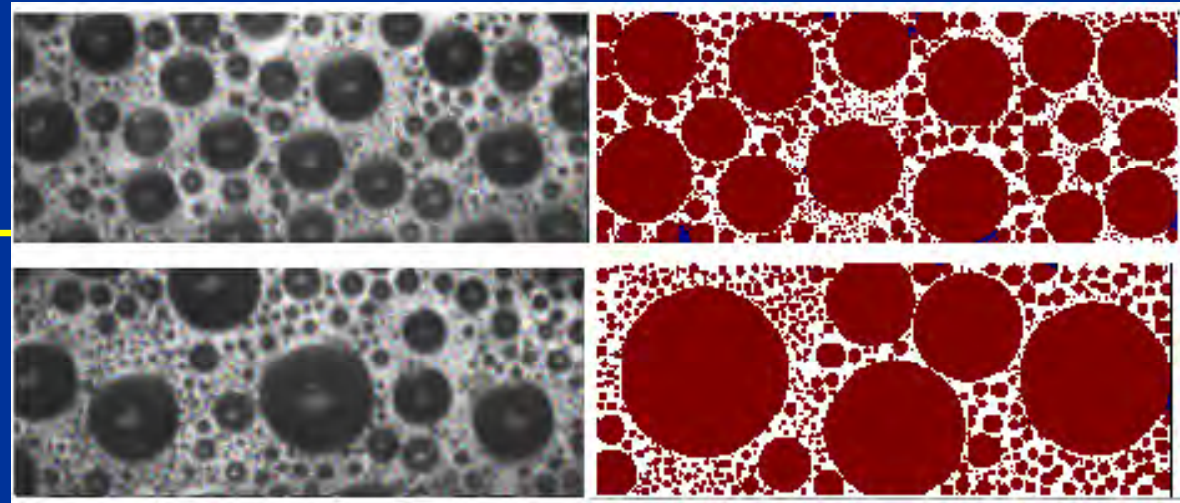


Isotherms of condensing droplet



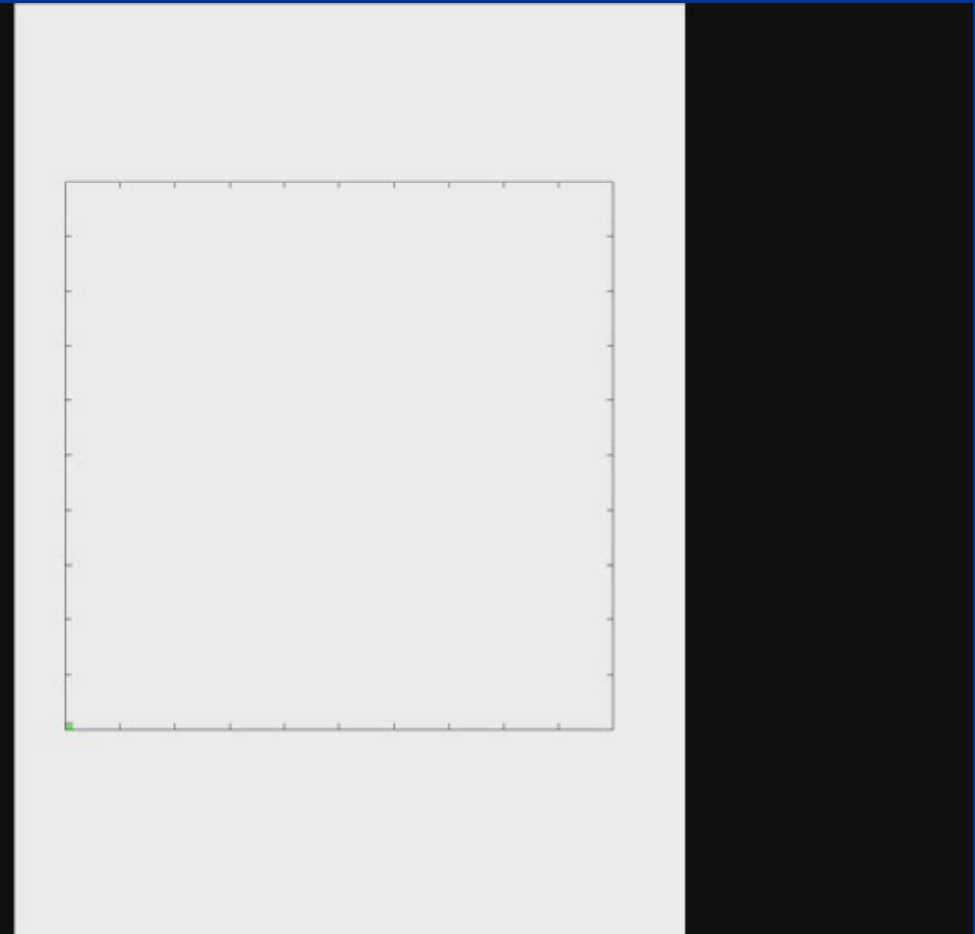
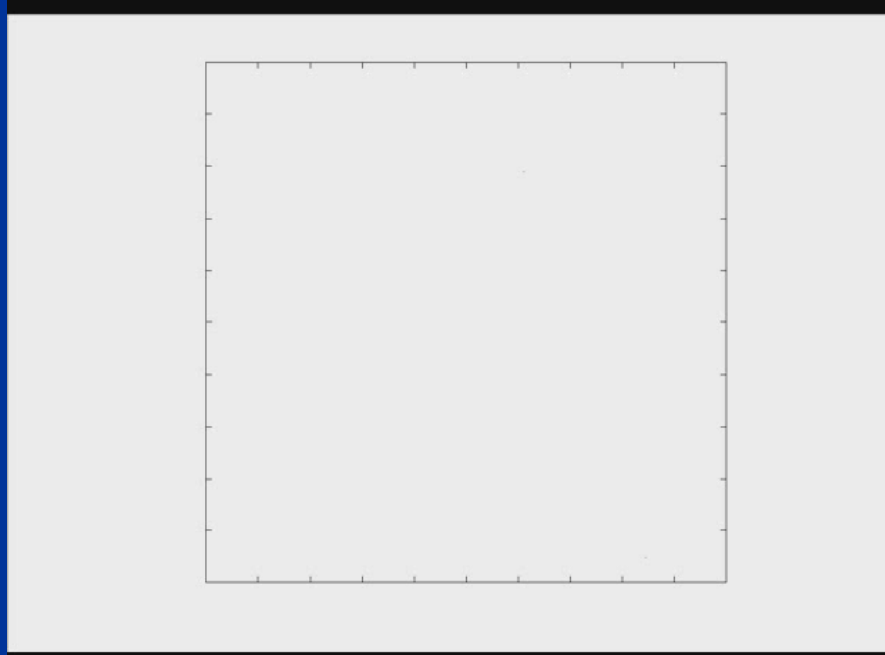
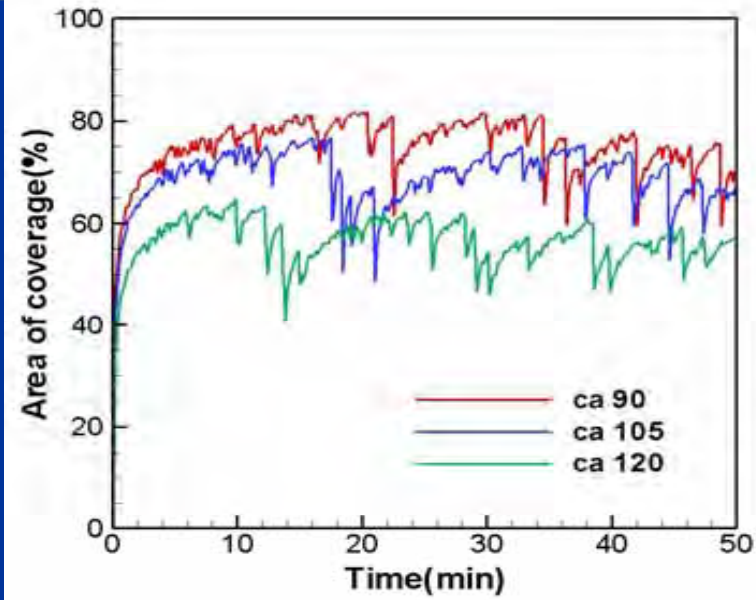
Liquid crystal thermography of condensing droplets

Dropwise condensation Simulation

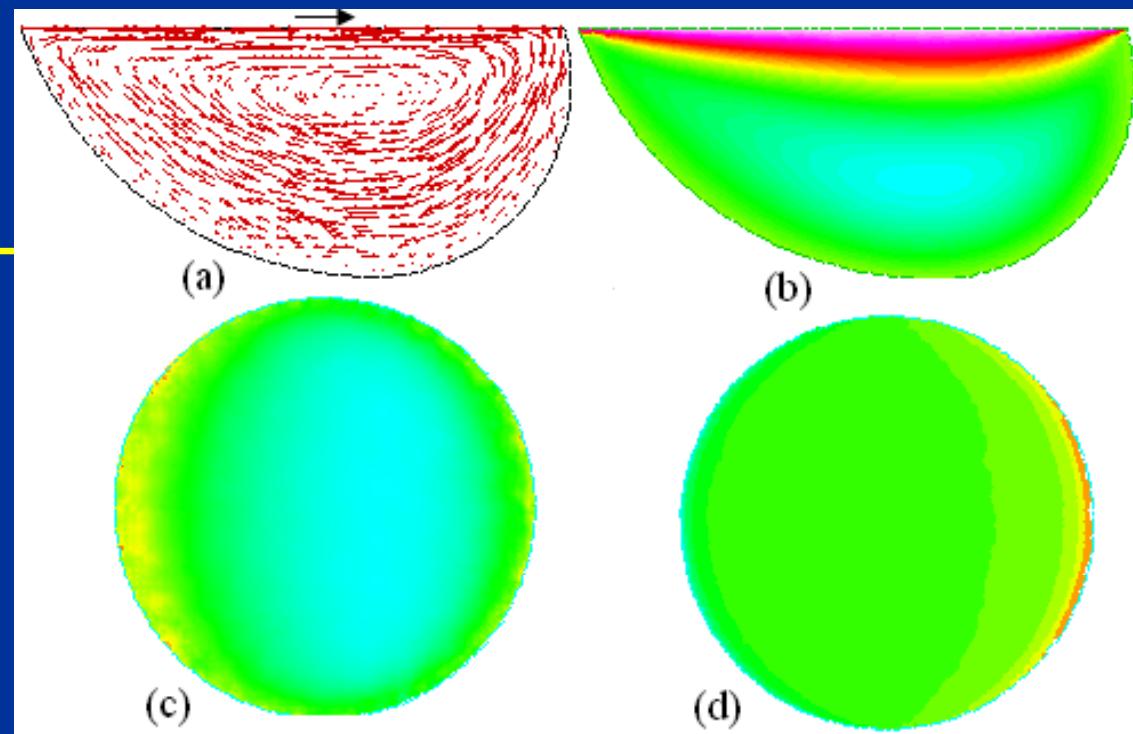
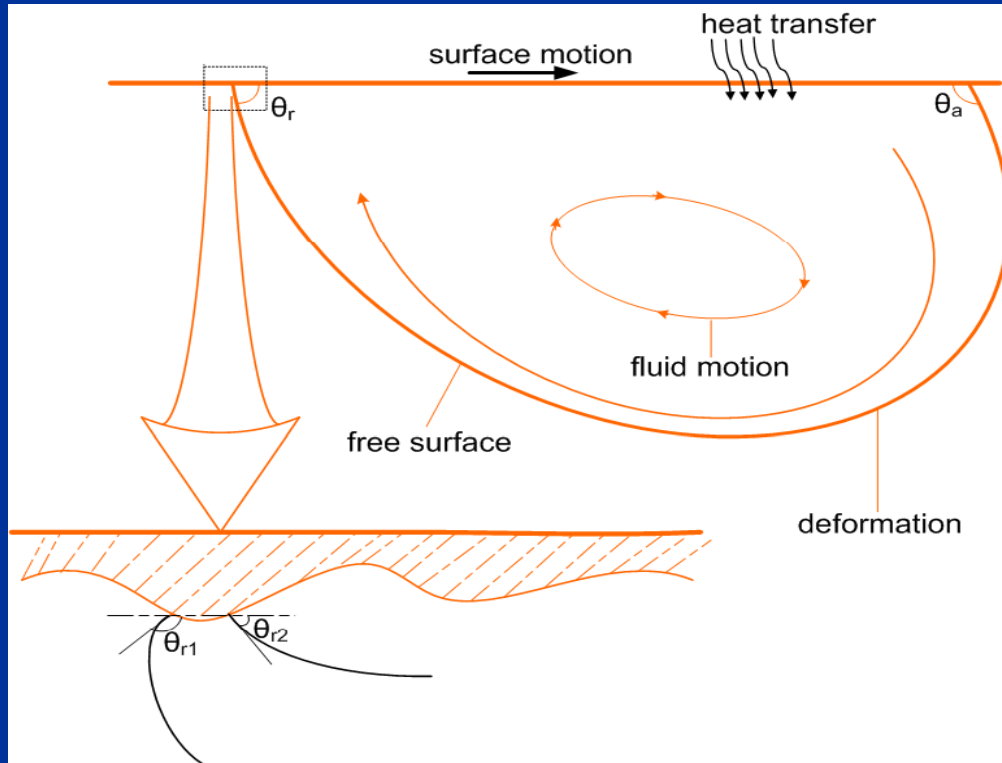


Experiments

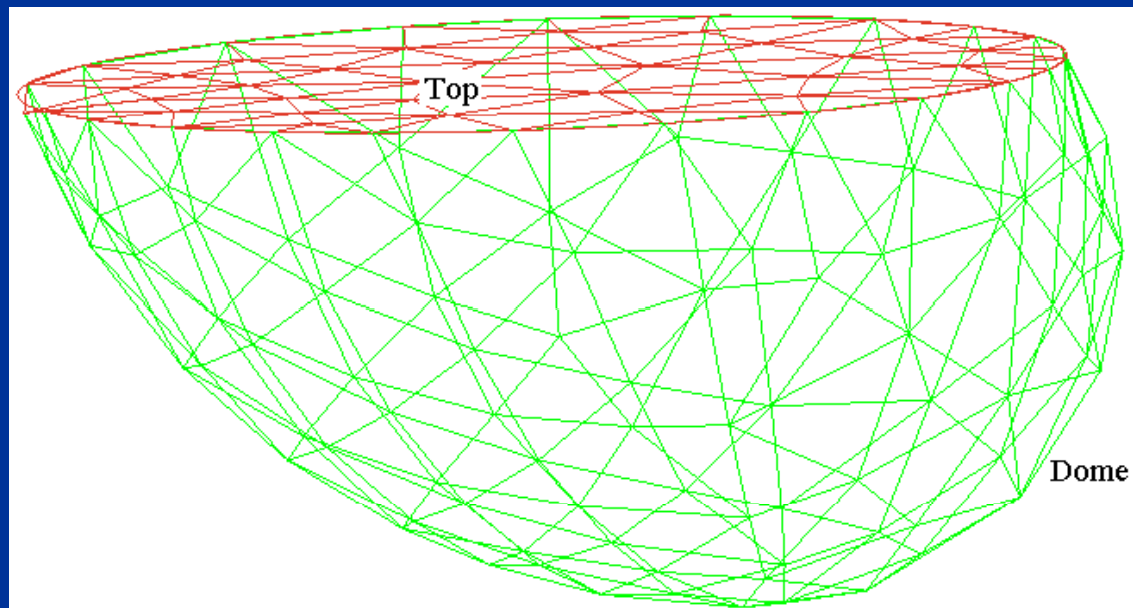
Simulation



Numerical simulation of pendant drops



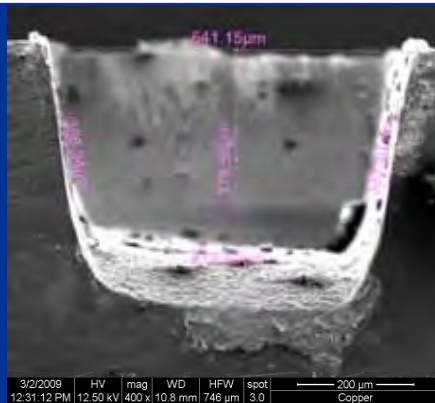
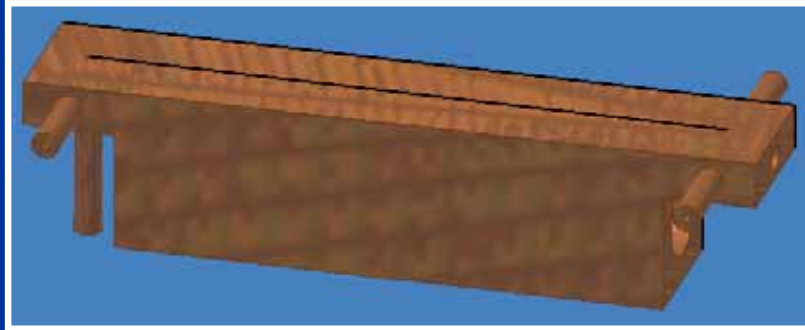
Velocity and temperature profile



Grid generated on the computational domain

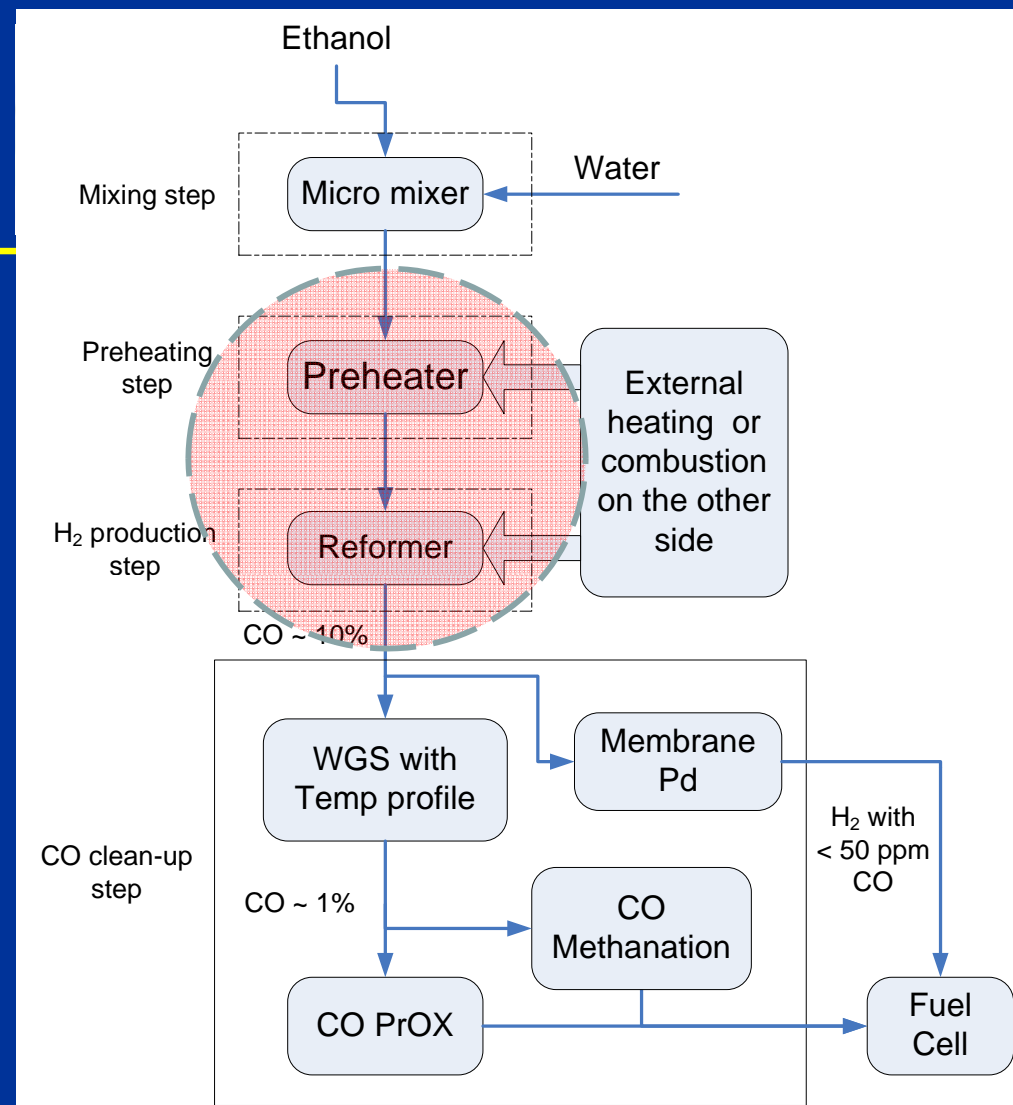
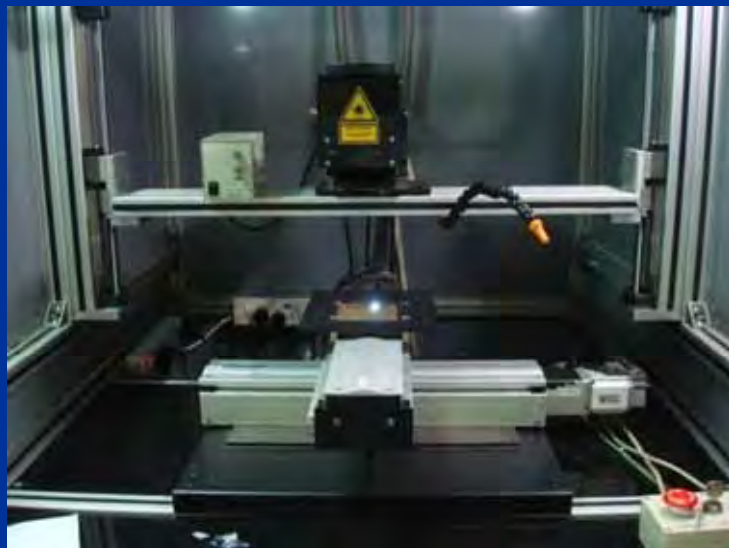
Sponsored by DAE/BRNS

Flow boiling in micro channels (Aim: Hydrogen production)

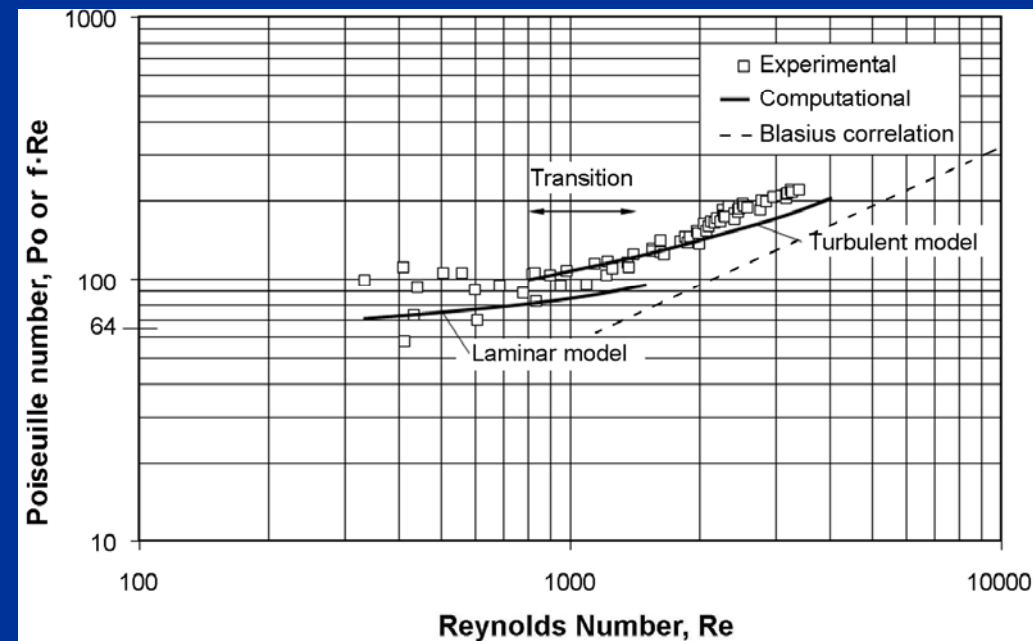
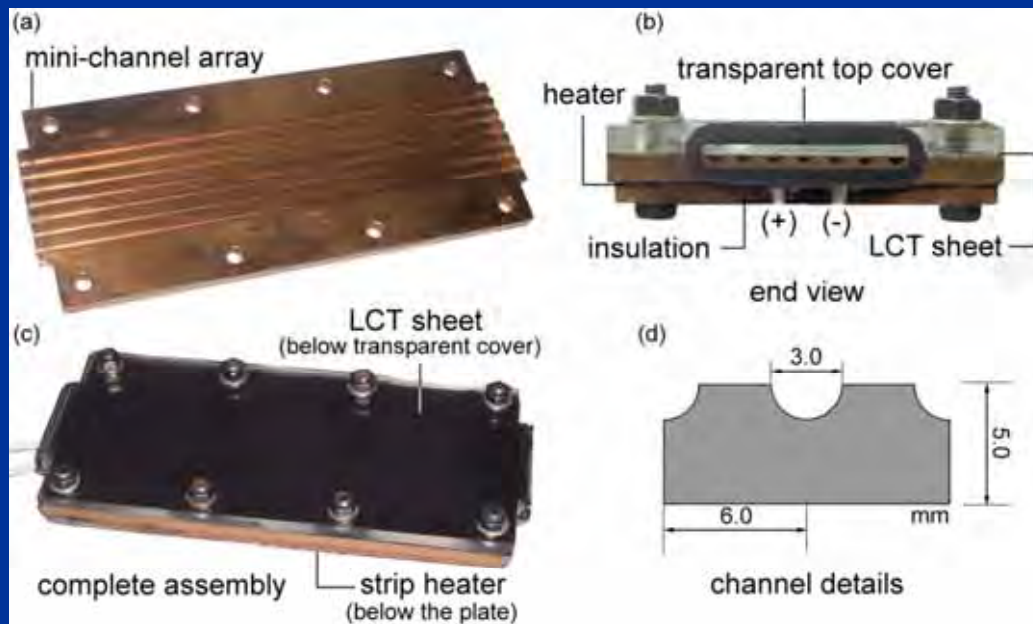
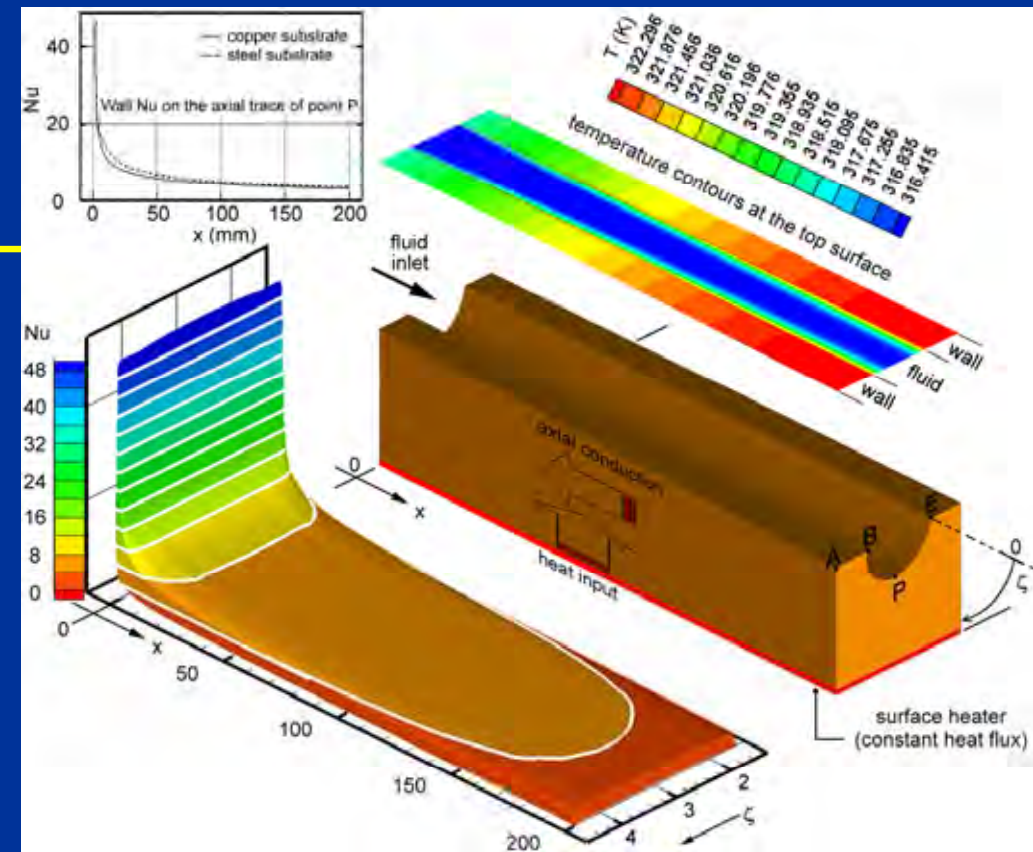
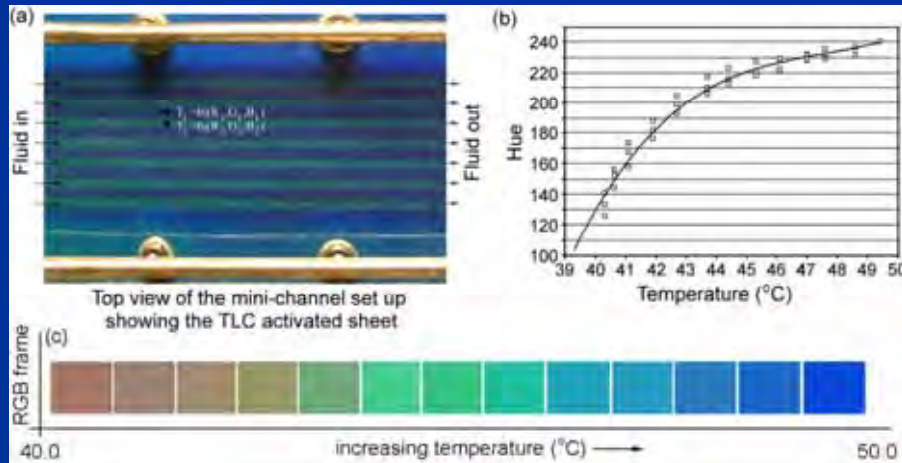


400 μm

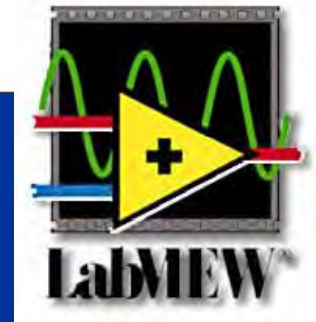
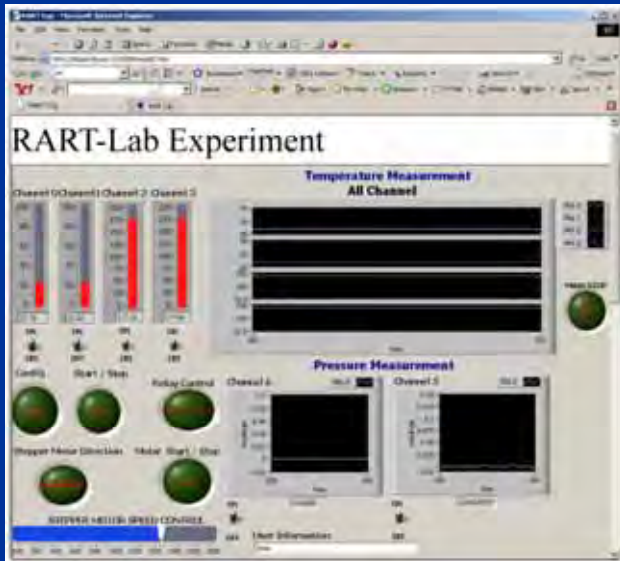
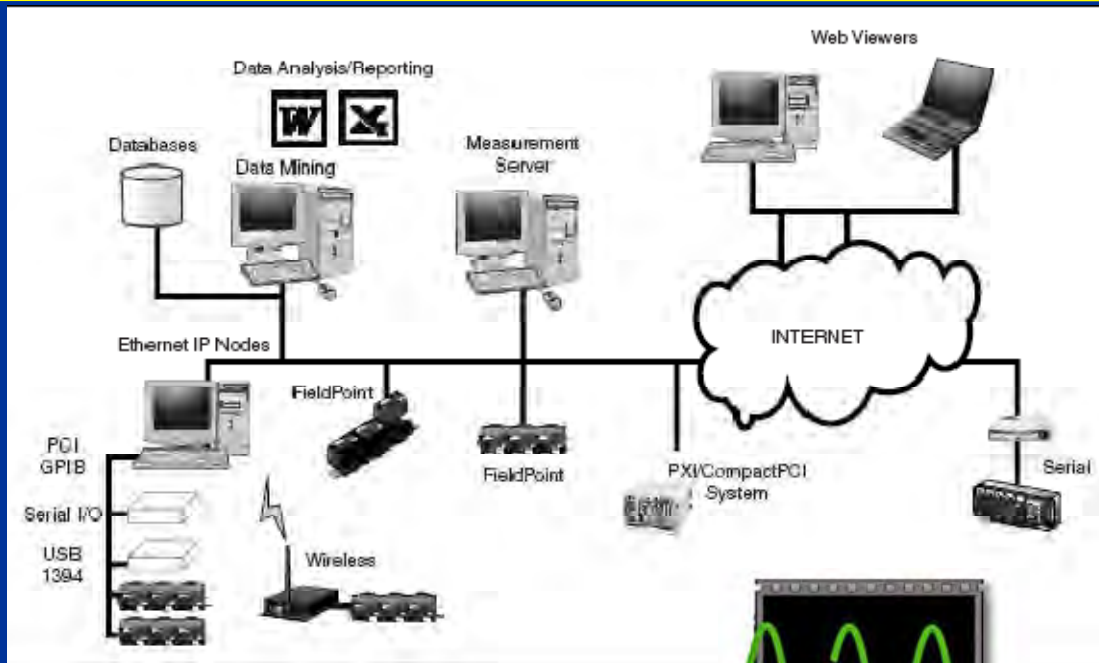
Laser micromachining



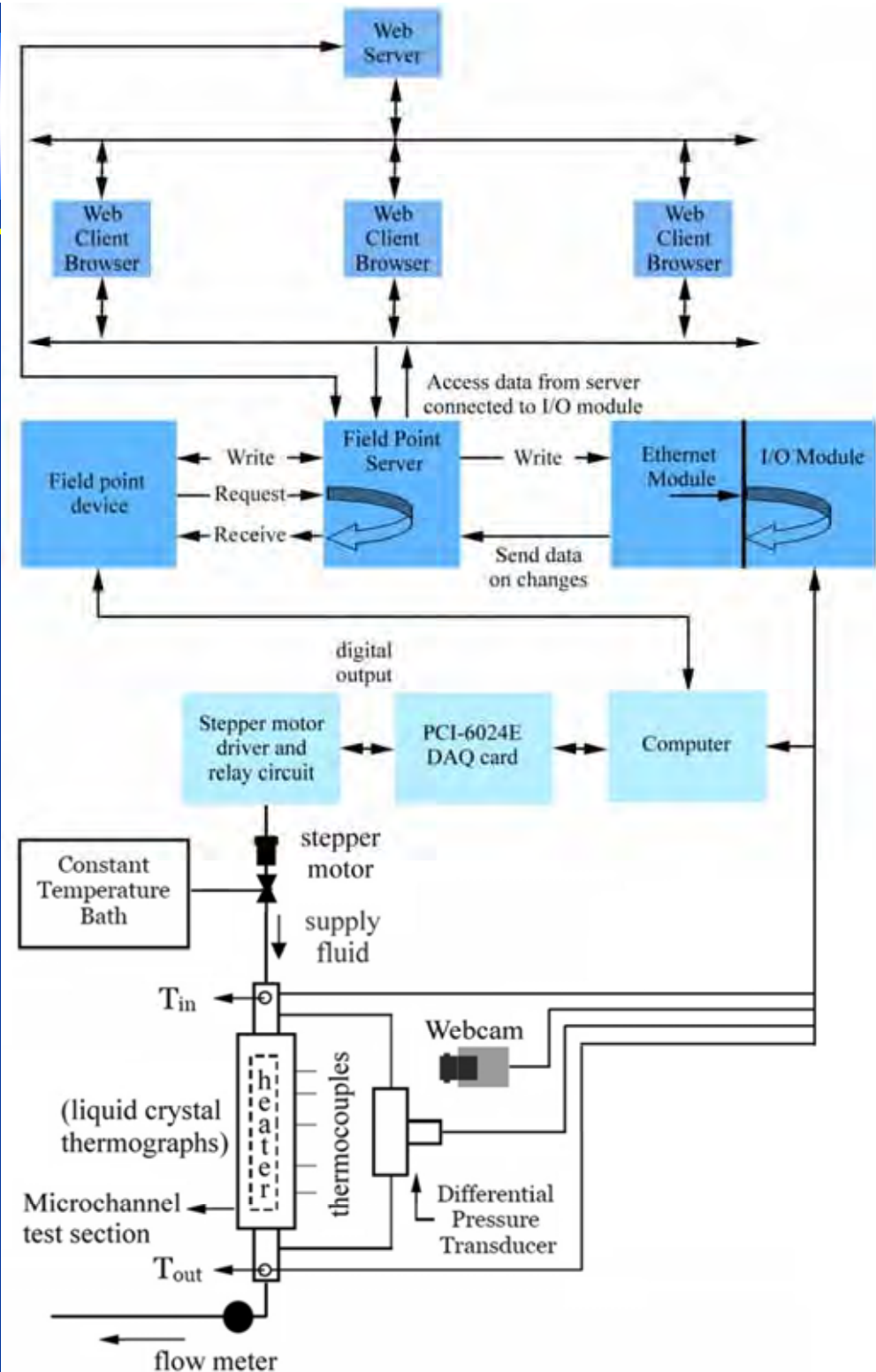
Liquid crystal thermography of developing single-phase flows



Remote Access Real Time Laboratory (Internet based experiments)



This development has led to a large sponsored project from MHRD





Undergraduate laboratory development

Energy Systems

- 1.2 kW Nexa PEM Fuel Cell Unit
- Parabolic Solar Concentrator
- Flat Plate Solar Collector
- Solar PV System
- Solar Cooker

Heat Transfer

- Two-phase Flow Patterns Demonstration Unit
- Two-phase Thermosyphon Unit
- Pulsating heat pipe visualization unit
- Eight other experiments being developed/ duplicated under the capacity expansion drive



Teaching experience (Regular courses)

- Course developed

- Liquid-Vapor Phase-Change Technology

- Course instructor

- Heat and Mass Transfer ☀
(ME 341: UG compulsory)
- Boiling and Condensation ☀
(ME 742: PG elective)
- Conduction and Radiation ☀
(ME 641: PG compulsory)
- Liquid-Vapor Phase-Change Technology ☀
(ME 639: PG elective)
- Energy Conversion Systems (I)
(ME 301: UG compulsory)
- Nuclear Power Engineering (invited lectures)
(NT 611: UG/PG elective)

- Course tutor/ Laboratory Instructor

- Fluid Mechanics and Rate Processes
(ESO 212: UG compulsory)
- Technical Arts Laboratory
(TA 201: UG compulsory)
- Heat Transfer Laboratory
(ME 471: UG compulsory)
- Thermodynamics
(ESO 202: UG compulsory)
- Communication Skills ☀
(COM 200: UG compulsory)
- Introduction to the Profession
(ME 100: UG compulsory)

☀ Student reaction survey score > 3.5/4.



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Teaching experience (Special Courses)

- Lecture Series (2 weeks) on “**Pulsating Heat Pipes**” delivered at five universities in Thailand during September, 2006.
- Graduate Course (Short Term - 24 hrs, 12 Graduate Students) on "**Heat Pipe Science and Technology**"- Summer Vacation 2005 (8 weeks) at Federal University of Santa Catarina, Florianópolis, Brazil.
- **Quality Improvement Program (QIP)/** Short term courses (03).
- **Industrial Heat Transfer Systems with Phase-change:** in-house training to about 80 industry participants at Mumbai and Delhi.

Teaching Assistant during M. Tech. Program at IIT Kanpur

TA 101 and ME 741



M. Tech. / Ph. D. thesis advising

M. Tech. theses advising

- **Completed: 15 (05 as co- advisor)**
- **Ongoing students: 03**

Ph.D. theses advising

- **Ongoing students: 04 (02 as co-advisor)**

Title 1: Flow boiling of ethanol-water mixtures in narrow channels.

Title 2: Two-phase passive cooling techniques for nuclear reactors.

Title 3: Droplet dynamics on textured engineered surfaces (with Dr. K. Muralidhar).

Title 4: Pulsating flow in micro channels (with Dr. P. K. Panigrahi).



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Academic/Research visits on invitation

- Center for Thermal Sciences (CETHIL) at INSA-Lyon, France, May-July 2008 (10 weeks).
- Heat Pipe Laboratory, University of Chiang Mai, Thailand, September 2006 (2 weeks).
- Federal University of Santa Catarina, Florianópolis, Brazil, May 2005 (10 weeks).

Review work for international journals

ASME Journal of Heat Transfer, International Journal of Heat and Mass Transfer, International Journal of Thermal Sciences, AIAA Journal of Thermophysics and Heat Transfer, Heat Transfer, Engineering, Applied Thermal Engineering, International Heat Pipe Conference, Indian Society for Heat and Mass Transfer



Administrative experience

Institute

- Treasurer of Alumni Association, IIT Kanpur since April 2008
- Nominated member of the academic senate of IIT Kanpur, December 2006 - November 2007
- Nominated member of the academic senate of IIIT-DM, Jabalpur (MP), June 2006 - present
- Chairman of Institute Transport Users Committee since August 2006 - September 2008
- Hostel Warden (Hall VII) July 2005 - June 2008, Warden-in-charge (March 2007 - June 2008)
- Faculty Counselor, Counseling Service, IIT Kanpur
- Member of Advisory Committee of the Dean, Resource Planning and Generation.
- Member of IITK Golden Jubilee Celebrations' Planning and Coordination Committee.
- Member of Students' Festival Pruning Committee.
- Participation in GATE/JEE operations.
- Various other institute level committees.



Administrative experience

Department

- Coordinator of the Heat Transfer and Refrigeration/AC Laboratory w. e. f August 2005.
- Web-page coordinator from 01 September 2007 - 31 August 2008.
- Member of B. Tech. Project Evaluation Committee from 01 June 2006 - 31 May 2007.
- Member of Departmental Post Graduate Committee 01 December 2006 - 31 August 2008.
- Seminar Coordinator from 01 September 2005 - 31 August 2007.
- Member of ME Conference Room Renovation Committee, 2006.
- Coordinator of Winter Industrial Tour for B. Tech. students, December 2004.

Other responsibilities

- Course coordinator/ Workshop organization (3)
- Treasurer, **Shiksha-Sopan**, a voluntary organization run by IITK community working for socially and economically backward society living in villages around IIT Kanpur, 2008-2011.
- President, **Shiksha-Sopan**, 2005-2008.
- Faculty Advisor, **Maharashtra Mandal**, IIT Kanpur.



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Keynote lectures/ Invited Talks

(after joining IIT Kanpur)

International

- 1. Roadmap to Realistic Modelling of Closed Loop Pulsating Heat Pipes,**
9th Int. Heat Pipe Symposium, Kuala Lumpur, Malaysia, 2008.
- 2. Multiple Steady States of a Pulsating Heat Pipe,**
7th Minsk Heat Pipe Seminar , Minsk, Belarus, September 2008.
- 3. Phase-Change Heat Transfer Activities at IIT Kanpur,**
CETHIL, Center of Thermal Sciences, INSA de Lyon, France, May 2008.
- 4. Understanding Thermo-hydrodynamics of Pulsating Heat Pipes,**
Chaing Mai University, Thailand, September 2006.
- 5. Emerging Importance of Microscale Heat Transfer,**
Federal University of Santa Catarina, Florianopolis, Brazil, June 2005.
- 6. Closed and Open Loop Pulsating Heat Pipes,**
13th Int. Heat Pipe Conf., Shanghai, China, 2004.



Publications in refereed journals (from IITK)

1. Revellin R., Lips S., Khandekar S. and Bonjour J., **Local entropy generation for saturated two-phase flow**, Energy-The International Journal, Elsevier, Accepted for publication, 2009.
2. Rao M. and Khandekar S., **Simultaneously developing flows under conjugated conditions in a mini-channel array: Liquid crystal thermography and computational simulations**, Heat Transfer Engineering , Vol. 30, Issue 10, 2009.
3. Yang H., Khandekar S. and Groll M., **Performance Characteristics of Pulsating Heat Pipes as Integral Thermal Spreaders**, Int. J. of Thermal Sciences, May 2008 (available online).
4. Khandekar S., Gautam A. P. and Sharma P., **Multiple Quasi-Steady States in a Closed Loop Pulsating Heat Pipe**, Int. J. of Thermal Sciences, Vol. 48, Issue 3, pp. 535-546, 2009.
5. Soundra Pandian K. K., Rao M. and Khandekar S., **Remote Access Real Time Laboratory: Process Monitoring and Control through Internet Protocol**, Int. J. of Mechanical, Engineering Education, Vol. 36, Issue 3, pp. 207-220, 2008.
6. Khandekar S., Joshi Y. and Mehta B., **Thermal Performance of Closed Two-Phase Thermosyphon using Nanofluids**, Int. J. of Thermal Sciences, Vol. 47, Issue 6, pp. 659- 667, 2008.
7. Yang H., Khandekar S. and Groll M., **Operational limit of closed loop pulsating heat pipes**, Applied Thermal Engineering, Vol. 28, pp. 49-59, 2008.
8. Khandekar S. and Groll M., **Pulsating Heat Pipes: Attractive Entrants in the Family of Closed Passive Two-Phase Systems**, J. of Energy, Heat and Mass Transfer (Special Issue), Vol. 26, pp. 99-115, 2004.

Two manuscripts are under review in refereed international journals



Publications in refereed journals (during doctoral research)

1. Khandekar S. and Groll M., **An Insight into Thermo-Hydraulic Coupling in Pulsating Heat Pipes**, Int. J. of Thermal Sciences, Vol. 43/1, pp. 13-20, 2004.
2. Charoensawan P., Khandekar S., Groll M., and Terdtoon P., **Closed Loop Pulsating Heat Pipes-Part A: Parametric Experimental Investigations**, Applied Thermal Engineering, Vol. 23/16, pp. 2009-2020, 2003.
3. Khandekar S., Charoensawan P., Groll M., and Terdtoon P., **Closed Loop Pulsating Heat Pipes-Part B: Visualization and Semi-Empirical Modeling**, Applied Thermal Engineering, Vol. 23/16, pp. 2021-2033 , 2003.
4. Khandekar S., Dollinger N. and Groll M., **Understanding Operational Regimes of Pulsating Heat Pipes: An Experimental Study**, Applied Thermal Engineering, Vol. 23/6, pp. 707-719, 2003.
5. Groll M. and Khandekar S., **Pulsating Heat Pipes: A Challenge and Still Unsolved Problem in Heat Pipe Science**, Archives of Thermodynamics, Vol. 23/4, pp. 17-28, 2002.
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3. Khandekar S. and Gupta A., **Embedded Pulsating Heat Pipe Radiators**, Proc. 14th International Heat Pipe Conference (IHPC), Florianópolis, Brazil, April, 2007.
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2. Khandekar S., Groll M., Luckchoura V., Findl W. and Zhuang J., **Micro Heat Pipes for Stacked 3D Microelectronic Modules**, Proc. of InterPACK'03, ASME Int. Electronic Packaging Technical Conf. and Exhibition, Paper No. 35109, ASME CD-ROM, ISBN 0-7918- 3674-6, Hawaii, USA, 2003.
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Book/Book Chapter/ Adaptation (completed)

1. Thermal Sciences by Merle C. Potter, Elaine P. Scott adapted for Indian market, Thomson Press, ISBN-10: 0534385214, (Indian Edition under print), 2008.
2. Engineering Thermodynamics by Lynn D. Russell and George. A. Adebiyi adapted for Indian market, Oxford University Press, ISBN 0-19-568905-4 (Indian Edition), 2007.
3. Introduction to Fluid Mechanics by E. Shaughnessy, I. Katz and J. Schaffer adapted for Indian market, Oxford University Press, ISBN 0-19-567783-8 (Indian Edition), 2006.
4. Micro Heat Pipes (invited review article), Groll M. and Khandekar S., Heat Exchanger Design Handbook, - Chapter on Microscale Boiling and Condensation, Begell House, 2003.

Ongoing activity

Principles of Heat Transfer

Co-authorship with Kreith and Bohn
Thomson Press (Cengage Learning)



Summary

- Last four and a half years have been very satisfying in terms of professional as well as personal development.
- Developed a state-of-the-art experimental heat transfer research laboratory.
- Developed vibrant international contacts/ research collaboration.
- Completed 4 sponsored projects from ISRO/BRNS/DAE/(IITK) – 75 lacs.
- Ongoing 3 sponsored projects from DAE/MHRD/DST – 250 lacs.
- All publications so far have been by M. Tech. students (Total: 08).
- Book writing/adaptation work has been carried out – Ongoing.
- Developed one PG course/ UG laboratory experiments.
- Student reaction survey score of above 3.5 in many UG/PG courses.
- Contributed in administrative tasks at departmental/ institute level.



**Department of Mechanical Engineering
Indian Institute of Technology Kanpur
Kanpur 208016
India**

Thank you