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Phase-Change Heat Transfer at Micro/Nanoscale: from

Fundamentals to Manufacturable Devices

With the increasing power density of electronics, thermal management is becoming critically important for many civil and military systems, including the next generation computer chips, high power lasers and electrical propulsion. Through the use of latent heat, phase-change heat transfer has been well recognized as a potential solution to high power electronics. On the other hand, phase-change heat transfer is not only the key to many traditional energy production systems such as coal-fired and nuclear power plants, but also will play a key role in renewable energy systems. For example, 100 W/cm² is expected from 1000-sun concentration photovoltaics (CPV) and 1000 W/cm² from light emitting diodes (LED). For extreme high heat flux applications along with the size and weight constraints, conventional heat sinks or spreaders become severely inadequate.

Owing to the advances in micro-/nano- fabrication and surface chemistry, phase-change heat transfer can be greatly manipulated with nanostructures, from both surface area change and wettability control. However, to take the best advantage of micro/nano-structuring, heat transfer surfaces need to be carefully designed. In this talk, we will show how we design and fabricate hybrid wicking structures for phase-change heat transfer. We have designed micromesh-enhanced microchannels for capillary evaporation and micro-patterned nanowire arrays for enhanced pool boiling through improved water spreading. Our efforts in developing flexible thermal ground planes (heat pipes) and nanostructured microchannel heat sinks will also be discussed.

Short Bio:

Dr. Ronggui Yang is the S.P. Chip and Lori Johnson Faculty Fellow in Engineering, an Associate Professor of Mechanical Engineering, and a Faculty Fellow in Materials Science and Engineering program at the University of Colorado at Boulder. Dr. Yang received his Ph.D with Prof. Gang Chen in Mechanical Engineering from MIT in February 2006. Since January 2006, he started his faculty career as an assistant

professor at CU-Boulder and has been promoted to associate professor with early tenure in summer 2011 (two-year ahead of the normal clock at CU-Boulder). Prior to MIT, he had a master's degree in MEMS from UCLA in 2001, a master's degree in Engineering Thermophysics from Tsinghua University in Beijing in 1999, and a Bachelor's degree in Thermal Engineering from Xi'an Jiaotong University in 1996. His research interests are on the fundamentals of nanoscale transport phenomena and the applications of micro/nanotechnologies for energy conversion, storage and thermal management. Dr. Ronggui Yang has published more than 80 journal papers, delivered ~60 invited seminars and is associated with >130 invited and contributed conference talks and posters that garnered numerous best paper/presentation/poster awards. His journal papers are highly cited with an annual citation > 500 times in 2012 according to ISI Web of Science (~700 annual citation in 2012 according to Google Scholar). His innovative research has won him numerous awards including 2010 ASME Bergles-Rohsenow Young Investigator Award in Heat Transfer, an NSF CAREER Award in 2009, the MIT Technology Review's TR35 Award and the DARPA Young Faculty Award in 2008, the Goldsmid Award for Research Excellence in Thermoelectrics in 2005, and a NASA Tech Brief Award for a Technical Innovation in 2004. He has also won the Provost's Achievement Award (2012), the Dean's Performance Award (2010), the Woodward Outstanding Faculty of Mechanical Engineering (2011) and the Outstanding Research Award in Mechanical Engineering (2008 & 2013) from the University of Colorado at Boulder. He has been endowed with the S.P. Chip and Lori Johnson Faculty Fellow for 2013-2017 and the Sanders Faculty Fellow for 2008-2012. Dr. Yang regularly serves as a reviewer for about 50 prestigious academic journals including Science, Nature, Physical Review Letters, Nano Letters, ACS Nano, Physical Review B, ASME transactions and IEEE Transactions. He is a proposal reviewer for for federal/non-profit funding agencies of US and ten other countries including China and European Research Council. Dr. Yang is an active member of ASME and has distinguishable services to ASME being a track/topic/symposium organizer or a session chair for hundreds of technical sessions for ASME conferences. Dr. Yang is currently the Vice Chair of the Nanoengineering for Energy and Sustainability Steering Committee of ASME Nanoengneering Council and the founding Vice Chair of the K-9 Technical Committee on Nanoscale Thermal Transport of ASME Heat Transfer Division.