

**From Electrospinning to Thermal Management in
Microelectronics, From Co-Electrospinning to Nanofluidics**

A.L. Yarin

University of Illinois at Chicago

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Abstract

In the first part, a novel method of enhancement of drop and spray cooling for microelectronic, optical and radiological elements and server rooms, which require extremely high heat fluxes, is discussed. The key idea of the method is to cover the heat transfer surfaces with electrospun nonwoven polymer or metal-plated "thorny devil" nanofiber mats. The experiments revealed that drop impacts on nanotextured surfaces of nanofiber mats produce spreading similar to that on the impermeable surfaces. However, at the end of the spreading stage the contact line is pinned and drop receding is prevented. All the mats appeared to be dynamically permeable for coolant drops. The enhanced efficiency of drop cooling in the presence of nanofiber mats observed experimentally results from full elimination of receding and bouncing of the drops, characteristic of the current spray cooling technology. Therefore, the drops evaporate completely, and the large cooling potential associated with the latent heat of evaporation is more fully exploited. This is paradoxical: the best cooling can be provided by a "furry overcoat"! Using this approach very high cooling rates of about 1 kW/cm^2 were achieved and the anti-Leidenfrost effect was discovered.

In the second part, carbon nanotubes are synthesized and self-assembled via co-electrospinning, emulsion electrospinning, or template electrospinning and subsequent carbonization. Then, controlled flows through macroscopically long ($\sim 1\text{cm}$) carbon nanotubes are demonstrated. It is shown that a higher flow rate of liquid in a bi-layer gas-liquid system can be achieved as compared to the case when the same liquid flows through the same tube subjected to the same pressure drop and occupies the whole bore. This means that it is possible to release more liquid than predicted by the Poiseuille law, even though in the bi-layer flow liquid does not occupy the whole cross-section. This paradoxical result is related to the fact, that the less viscous gas layer can flow much faster than the underlying liquid layer and entrain the latter via a significant shear stress. This quasi-giant-slip phenomenon occurs in relatively large nanotubes (of the order of 500 nm dia.) where the no-slip condition holds with sufficient accuracy.

Biography

MSc-1977 (in Applied Physics), PhD (in Physics and Mathematics)-1980, DSc (Habilitation, (in Physics and Mathematics)-1989. Affiliations: Junior&Senior Research Associate at The Institute for Problems in Mechanics of the Academy of Sciences of the USSR, Moscow (1977-1990) [and concurrently Professor at the Dept. of Molecular and Chemical Physics of The Physico-Technical Institute (1985 – 1989) and The Aviation Technology Institute, Moscow, USSR (1988-1990)]; Professor at The Technion-Israel Institute of Technology (1990-2006; Eduard Pestel Chair Professor in Mechanical Engineering at The Technion in 1999-2006); Distinguished Professor at The University of Illinois at Chicago, USA (2006-present); Fellow of the Center for Smart Interfaces at the Technical University of Darmstadt, Germany (2008-2012); Visiting Professor at Korea University (Seoul, S. Korea, 2013-present). Dr. Yarin was a Visiting Professor on sabbatical at the University of Wisconsin-Madison (Chem. Eng. Dept.) in 1996-1997, and at The University of Illinois at Chicago in 2003-2004. Prof. Yarin is the author of 3 books, 12 book chapters, 253 research papers, and 6 patents. He is one of the three co-Editors of "Springer Handbook of Experimental Fluid Mechanics", 2007, and the Associate Editor of the journal "Experiments in Fluids". He is also the Member of the International Editorial Advisory Board of the Bulletin of the Polish Academy of Sciences, and of the journal "Archives of Mechanics", as well as the Member of the Editorial Advisory Board of the journal "Electrospinning". Prof. Yarin was the Fellow of the Rashi Foundation, The Israel Academy of Sciences and Humanities, and was awarded Gutwirth Award, Hershel Rich Prize and Prize for Technological Development for Defense against Terror of the American-Technion Society.

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