

Active Transport of Nanomaterials Using Motor Proteins

**Final report for DOE-BES grant DE-FG03-03ER46024
(02/03 – 01/05)**

**Submitted to:
Dr. Timothy Fitzsimmons
The Division of Materials Sciences
Office of Basic Energy Science
U.S. Department of Energy**

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PRINCIPAL INVESTIGATORS: Prof. Henry Hess and Viola Vogel

SUMMARY

During the two year period of funding we have focused on the following topics: Guiding of microtubule movement on kinesin-coated, structured surfaces, directed assembly of oriented microtubule networks, and the interaction between synthetic materials and biological components in hybrid devices based on microtubules and kinesin motors. Additional efforts have been made and are still on-going in controlling the motor activity, and loading and unloading of cargo.

In all aspects, the collaboration with the team at Sandia has been critical. A constant intellectual and material connection has been maintained by frequent visits, videoconferences, and exchanges of parts and supplies, such as microfabricated structures and motor proteins. The scientific advances made through this collaboration have been documented in seven publications in high-impact journals and an encyclopedia, discussed in invited talks at the annual meetings of MRS and ACS, and publicized by journalists in “The Scientist” and “Nature Materials Nanozone”. One double Ph.D. degree in Bioengineering and Nanotechnology has been completed (John Clemmens).

List of accomplishments:

Peer-reviewed journals - published:

J. Clemmens, H. Hess, R. Lipscomb, Y. Hanein, K. Böhringer, C. Matzke, G. Bachand, B. Bunker, V. Vogel*: “Mechanisms of Microtubule Guiding on Microfabricated Kinesin-coated Surfaces: Chemical and Topographic Surface Patterns”, *Langmuir*, 19, 10967-10974 (2003)

H. Hess*, C. Matzke, R. Doot, J. Clemmens, G. Bachand, B. Bunker, and V. Vogel: "Molecular shuttles operating undercover: A new photolithographic approach for the fabrication of structured surfaces supporting directed motility", Nano Letters, 3, 1651-1655 (2003)

H. Hess*, G. D. Bachand, and V. Vogel: "Powering nanodevices with biomolecular motors", Chemistry – A European Journal, **10(9)**, 2110-2116 (2004)

J. Clemmens, H. Hess, R. Doot, C. M. Matzke, G. D. Bachand, V. Vogel*: "Motor-protein "roundabouts": Microtubules moving on kinesin-coated tracks through engineered networks", Lab on a Chip, **4(2)**, 83-86 (2004)

C. Brunner, K.-H. Ernst, H. Hess, V. Vogel*: "Lifetime of biomolecules in polymer-based hybrid nanodevices", Journal of Nanotechnology, **15(10)**, S540-S548 (2004)

H. Hess, J. Clemmens, C. Brunner, R. Doot, S. Luna, Karl-Heinz Ernst and V. Vogel: „Molecular self-assembly of "Nanowires" and "Nanospools" using active transport", webpublished by Nano Letters Feb-26-2005

Book chapters:

H. Hess, G. Bachand, and V. Vogel: "Motor proteins in synthetic materials and devices", in Encyclopedia of Nanoscience and Nanotechnology. Edited by James A. Schwarz, Cristian Contescu, and Karol Putyera, p.2201-2209 (Marcel Dekker, New York, 2004)

Other:

H. Hess and V. Vogel: "Nanotechnology to Go: Active Transport by Motor Proteins", SPIE Nanotechnology E-Bulletin, June 2004

H. Hess: "Nanobiotechnology: The Book", SPIE Nanotechnology E-Bulletin, September 2004

Press Resonance:

Nature Materials Nanozone News: "Reeling in Nanofilaments" by Philip Ball, 3/10/2005

The Scientist: "Alternative Energy for Biomotors" by Bennett Daviss, vol. 18, issue 18, 26, 9/27/2004

Invited Lectures (Henry Hess):

IEEE Conference on Nanodevices and Systems Integration, Miami, FL (2004)

227th ACS National Meeting, Anaheim, CA (2004)

Foundations of Nanoscience: Self-Assembled Architectures and Devices Conference,
Snowbird, UT (2004)

2004 Fall Meeting of the MRS, Boston, MA (2004)

Supported Students (1 Ph.D. graduated), Postdocs, and Faculty:

Professor Viola Vogel (until 4/2004) – now at the Institute for Biologically Oriented
Materials, Department of Materials, Swiss Federal Institute of Technology (ETH),
Zurich, Switzerland

Henry Hess (Research Assistant Professor)

Dr. John Clemmens (graduate student and postdoctoral researcher) – now at Micronics
Inc. (Redmond, WA)

Robert Doot (graduate Student)

Dr. Karl-Heinz Ernst (visiting scientist) – staff scientist at Molecular Surface
Technologies Group, Swiss Federal Laboratories for Materials Testing and Research
(EMPA), Dübendorf, Switzerland

Christian Brunner (visiting student) – graduate student at the Department of Materials,
Swiss Federal Institute of Technology (ETH), Zurich, Switzerland