STATISTICAL MODELS FOR BIOMOLECULAR SHUTTLES GLIDING IN MICROFABRICATED OPEN CHANNELS

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Abstract

Nature has evolved biomolecular motor proteins as active nanoscale transporters in cells. Integration of motor proteins in a microfluidic network allows a novel on-chip molecular cargo transport system. A common approach to achieve such a biomolecular motor-based microfluidic transport system employs microtubules, one of cytoskeletal components, gliding on a kinesin-coated glass surface as molecular shuttles carrying cargos. Because of their compact size, high chemomechanical energy transduction efficiency, and robust movement *in vitro*, kinesins are one of the most promising motor protein species to construct ATP-fueled manmade microdevices.

In this work, we modeled the behavior of microtubules when they land from a physiological buffer solution onto an open channel surface and are subsequently guided by a channel sidewall after colliding with the channel sidewall. Our first model predicts the probability of successful landing at a given channel site from a solid angle. The solid angle is determined by the physical constraints. When the incident angle at which microtubules collide with a channel sidewall is small, they are successfully redirected along the channel. Otherwise, they are bent up and lifted away from the kinesin-coated surface. Accounting for bending energy, we developed a statistical mechanics model to predict the success rate of guiding microtubules at a given incident collision angle θ_r.

Moreover, we carried out a series of microtubule gliding assays using microfabricated channels and observed both the microtuble landing and guiding events at varying channel width W and incident angles. The average microtubule length L was measured for each experiment and used to normalize the channel width W and sidewall height h. Epifluorescence microscopy with a 40x oil immersion

objective lens was used to record of each collision event. A successful guiding process was verified by ensuring that the microtubule remained in focus during their gliding motion parallel to the channel sidewall. The comparison indicates good agreement between our theory and experiments and validates our models.

Bibliography

Chih-Ting Lin received the B.S. degree in civil engineering and M.S. degree in applied mechanics from the National Taiwan University, in 1996 and 1998, respectively. He also received the M.S. and Ph.D. degree in electrical engineering and computer science from the University of Michigan, Ann Arbor, in 2003 and 2006, respectively.

Since September 2006, he has been with the National Taiwan University, where he is an assistant professor of the Graduate Institute of Electronics Engineering and the Department of Electrical Engineering. His current research interests include bio-MEMS, bio-chips, nano fabrication, and biomolecular detection technology.