NANO HIGHLIGHT
Hybrid Synthetic/Bio Motor/Generator

NSF NSEC Grant EEC 0425914

PIs: **Alex Zettl, George Oster, Jean Frechet, Michael Crommie, Carlos Bustamante**
University of California at Berkeley

Is it possible to mate a synthetic nanomotor to F_1-ATPase based chemical motor?

Researchers at the Center of Integrated Nanomechanical Systems (COINS), based at the University of California in Berkeley, have been working to understand synthetic and biological nanomotors. The Zettl group has nanofabricated synthetic motors based on multiwall carbon nanotubes (MWCNTs). MWCNTs are nested structures of concentric cylindrical graphene shells. Their atomically perfect structure should be ideal for creating nanoscale rotational bearings. Figure 1 shows a nanomotor in operation[2]. However, there are many important lessons to be learned from the design and operation of biological molecular motors. The methods of single molecule manipulation developed in the Bustamante group[3] are being used to investigate, one molecule at a time, the physical principles that govern the behavior of molecular motors. In the first phase of these endeavors, translational and rotational biological motors will be attached to nano-fabricated moving parts in order to drive them. Theoretical guidance is provided by the Oster group, which studies the biomechanics of molecular motors from the viewpoint of mesoscopic modeling[4]. These nanometer-sized, biochemically fueled devices will constitute the first step towards combining biological motors with artificial electrical and mechanical motors, and finally to a hybrid integrated system (Figure 2).

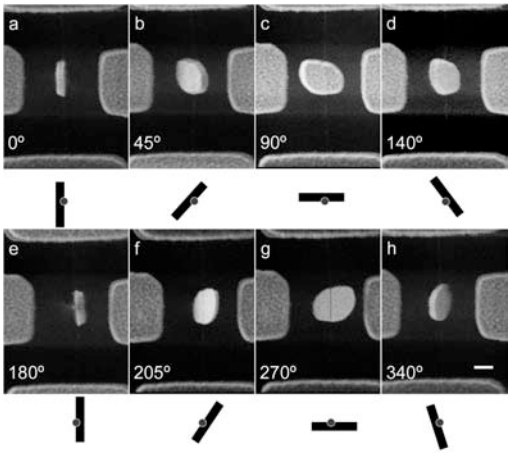

Fig 1. Micrographs of a nanomotor stepped through 360°. Scale bar 300 nm.

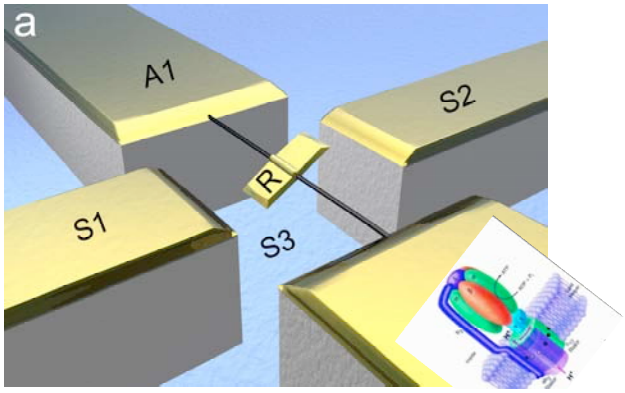

Fig 2. Schematic showing a chemical motor attached to a nanotube-based synthetic motor.

References

[1] For further information about this project link to http://nano.berkeley.edu/coins/.
[2] A. M. Fennimore, T. D. Yuzvinsky, W. Han, M. S. Fuhrer, J. Cummings, A. Zettl, Rotational actuators based on carbon nanotubes, *Nature* **424**, 408, 2003.
[3] Smith DE, Tans SJ, Smith SB, Grimes S, Anderson DL, Bustamante C. The bacteriophage straight phi29 portal motor can package DNA against a large internal force. *Nature* **413**:748-52 (2001).
[4] Sun, S., Wang, H., and Oster, G. Asymmetry in the F1-ATPase and its implications for the rotational cycle. *Biophys J.* (2004).