# Controllable single molecule gear

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An experimental demonstration is presented of the fundamental component of a planar single-molecule mechanical machinery: a molecule gear intentionally assembled on a Au(111) surface. A Scanning Tunneling Microscope (STM) is used as the sole tool to build, controllably manipulate and observe the molecule gear step by step rotation[1]. A hexa-*t*-butyl-pyrimidopentaphenyl- benzene ($C_{64}N_2H_{76}$; HB-NBP) molecule 1.3 nm in diameter was mounted and centered on one atomic scale axis on Au(111). Our investigation shows that the combination of molecule design, molecule manipulation protocol and surface atomic structure selection leads the functioning of the molecule gear. The rotation of this molecule gear is done step-by-step and totally under control, demonstrating nine stable stations in both rotational directions. Each station can be identified comparing calculated and experimental images. For each calculated image, the stable position of the gear was obtained using molecular mechanics calculations.

To bridge between the above molecule gear and solid state nanogears and to transmit the motion from (and to) the nanoscale to the mesoscale for possible applications like data input on an atomic scale circuit or information encoding, we present also the e-beam naofabrication of solid-state $SiO_2$ nanogears with diameters ranging from 350 nm to down to a 40 nm[2]. Those gears can be manipulated using an Atomic Force Microscope (AFM) tip on a polycrystalline gold surface, to construct a train of gears where mechanical motion can be transmitted from one to another by mastering the surface friction. In conclusion, we will discuss possible ways to bridge the remaining gap between the solid state 40 nm and the molecule 1.3 nm in diameter nanogears (or between a 15 nm thick solid state gear and a molecule gear 0.6 nm in height).

## References

[1] C. Manzano, W. -H. Soe, H. S. Wong, F. Ample, A. Gourdon, N. Chandrasekhar, and C. Joachim, Nature Materials, 8 (2009) 576

[2] J. Deng, C. Troadec, F. Ample, and C. Joachim, Nanotechnology, 22 (2011) 2275307

## Figures

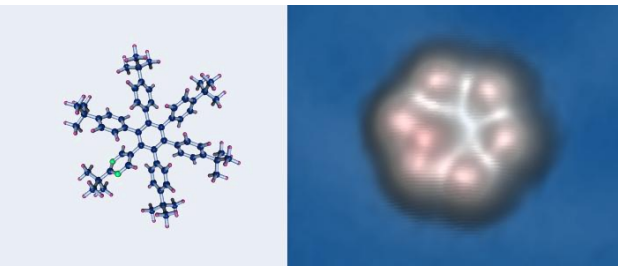

**Figure 1.** single gear molecule; ball-and-stick model (left) and LT-STM image (right).

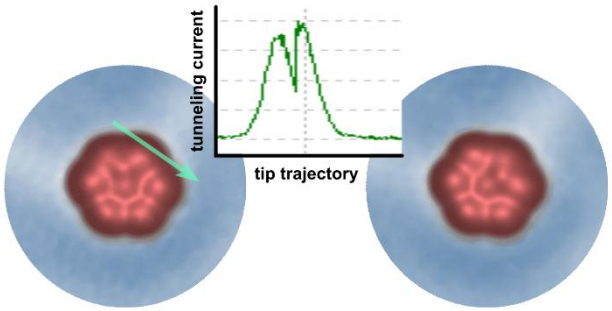


**Figure 2.** Controllable gear rotation from one station to another induced by a tip apex molecule manipulation. The molecule gear is mounted on the herringbone kink of Au(111) reconstructed surface. The rotation mechanics was followed by recording the tunneling current during the one step molecule gear rotation.