

**ФИЗИКО-ХИМИЧЕСКИЕ
ОСНОВЫ
НАНОТЕХНОЛОГИИ**

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5. АТОМНЫЙ ДИЗАЙН

What is Scanning Tunneling Microscopy?

- Allows for the imaging of the surfaces of metals and semiconductors at the atomic level.
- Developed by Gerd Binnig and Heinrich Rohrer at the IBM Zurich Research Laboratory in 1982.

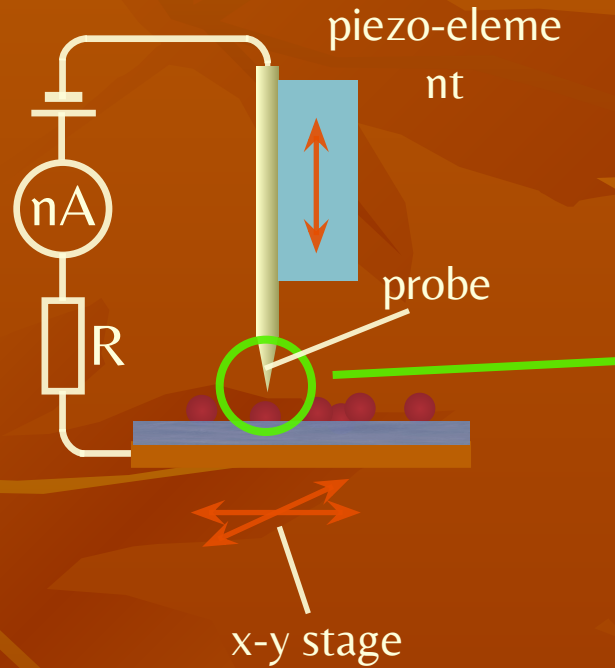
Binnig



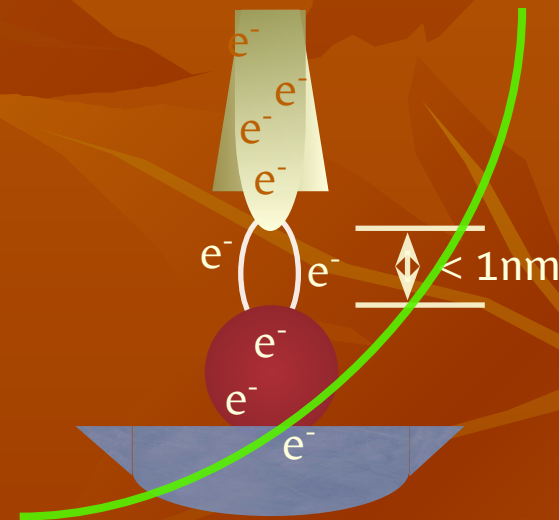
Rohrer

- The two shared half of the 1986 Nobel Prize in physics for developing STM.
- STM has fathered a host of new atomic probe techniques: Atomic Force Microscopy, Scanning Tunneling Spectroscopy, Magnetic Force Microscopy, Scanning Acoustic Microscopy, etc.

STM: scanning tunneling microscope

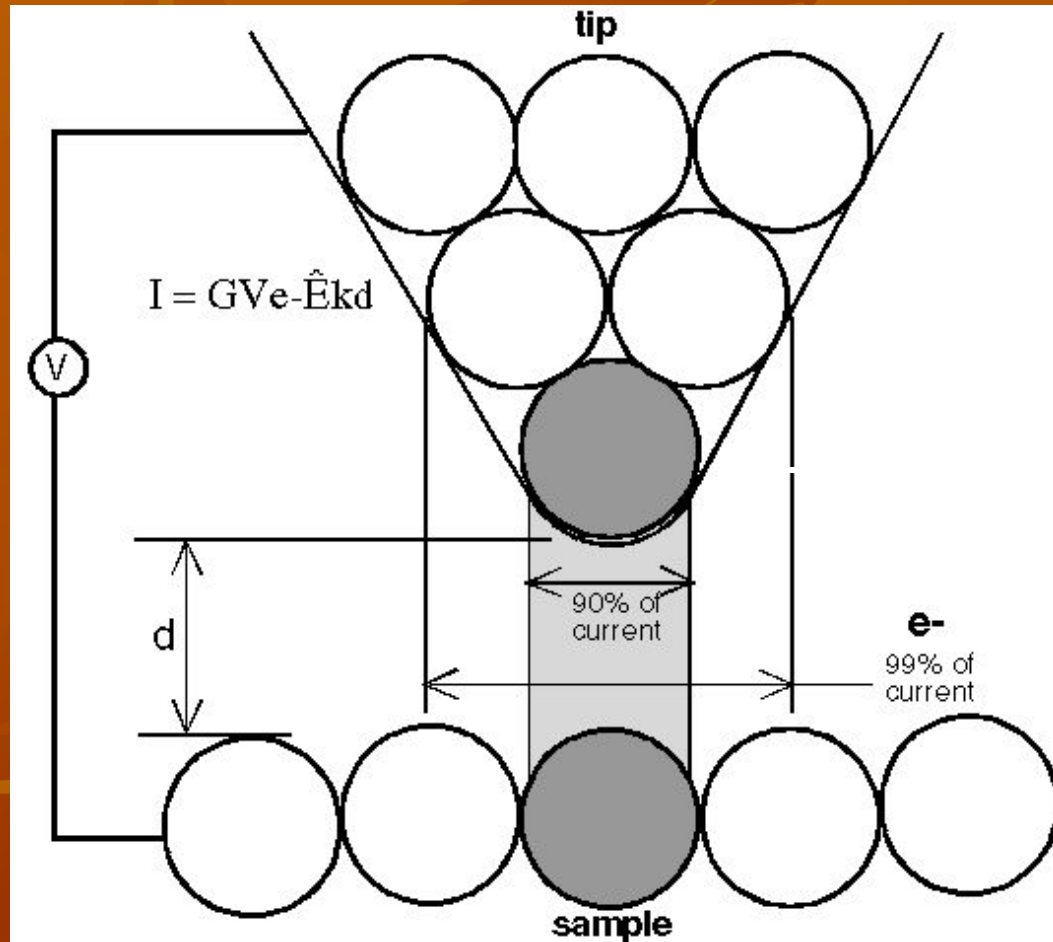


tunneling of electrons through air
between probe and surface



only conducting material

Basic Principles of STM



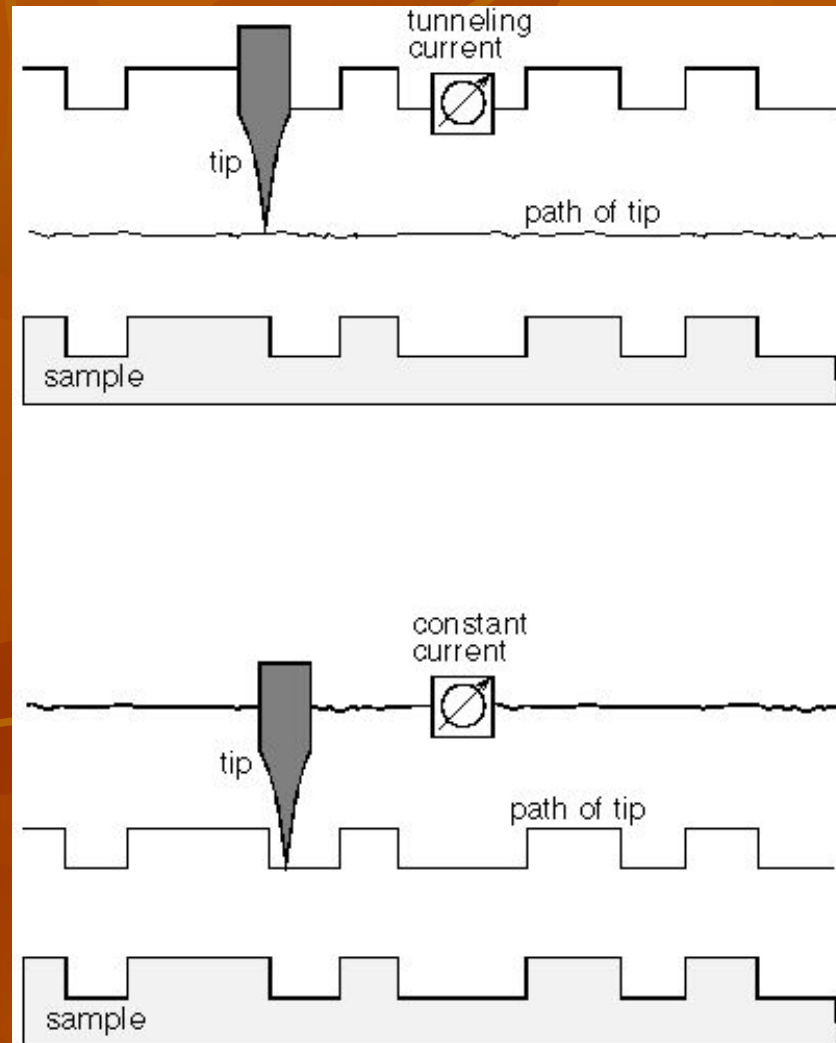
$d \sim 6 \text{ \AA}$

Bias voltage:
mV – V range

- Electrons tunnel between the tip and sample, a small current I is generated (10 pA to 1 nA).
- I proportional to $e^{-2\kappa d}$, I decreases by a factor of 10 when d is increased by 1 \AA .

Two Modes of Scanning

Constant
Height Mode



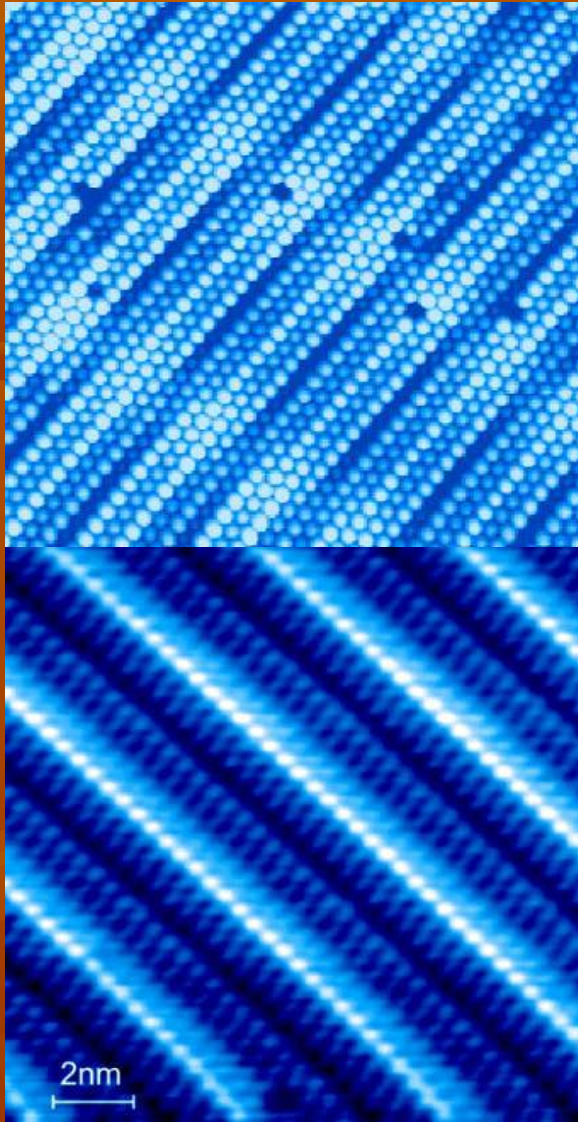
Constant
Current Mode

- Usually, constant current mode is superior.



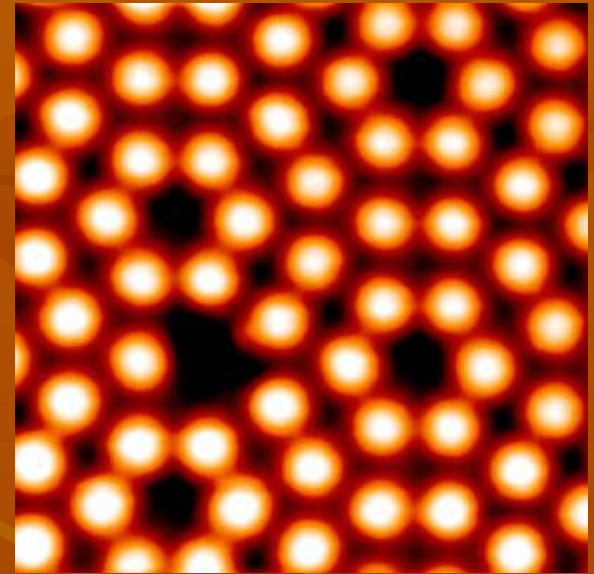
STM изображения

Examples of STM images...

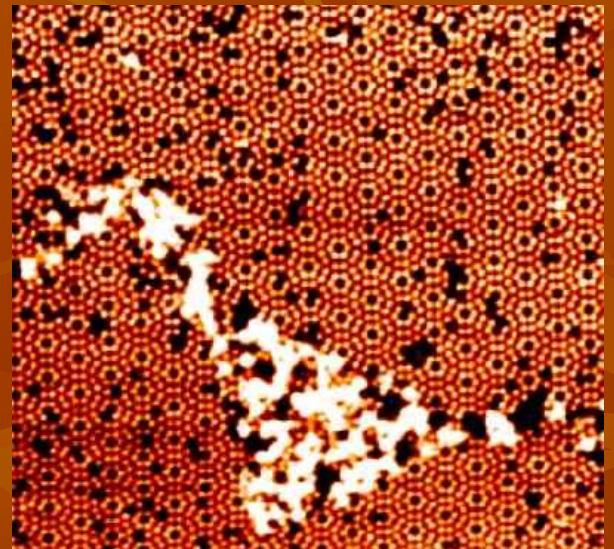


- Pt (100) with vacancies

- Si (111) 7x7 reconstruction

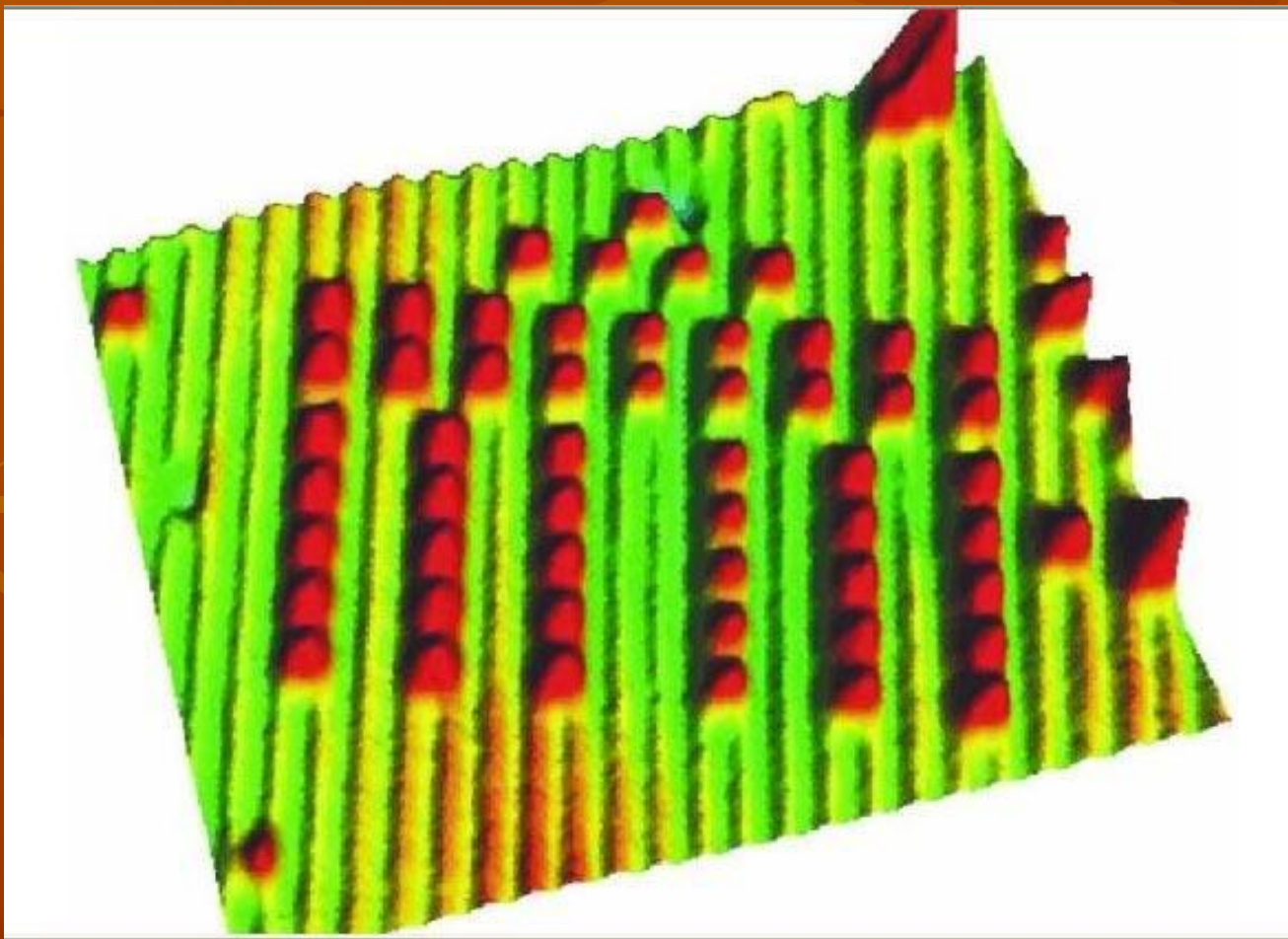


- Annealed decanethiol film on Au(111)

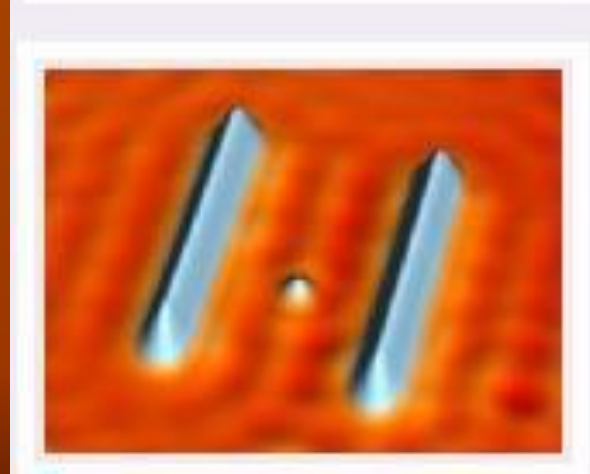


- Si (111) with terraces and

Бранденбургские ворота



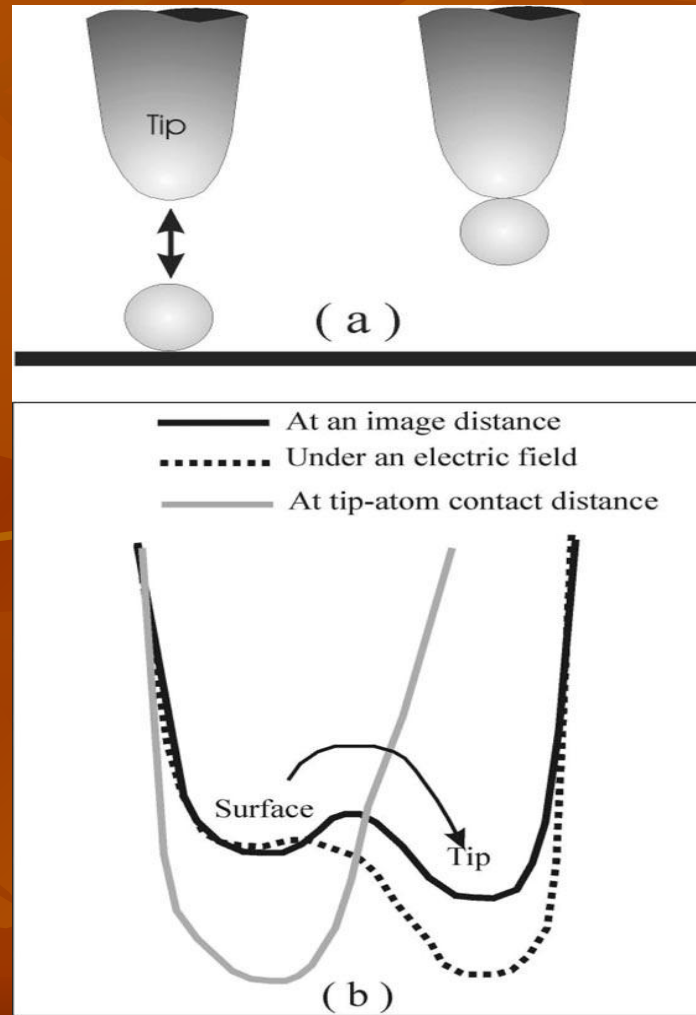
Диффузия атомов на поверхности



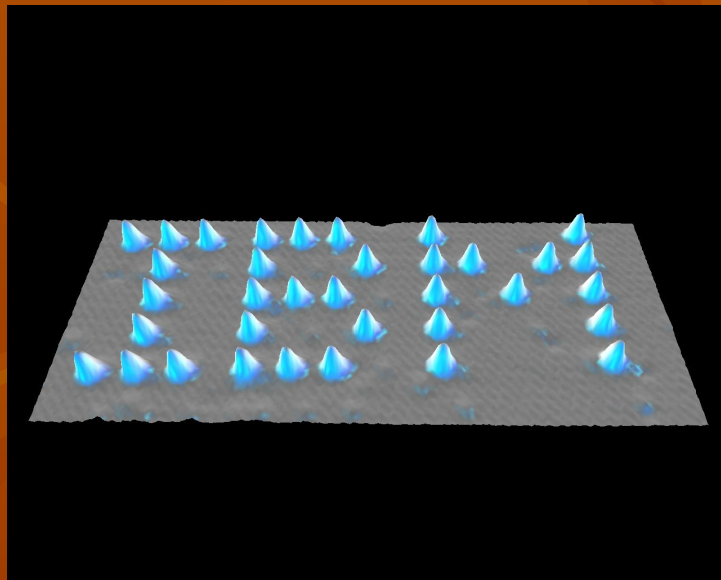
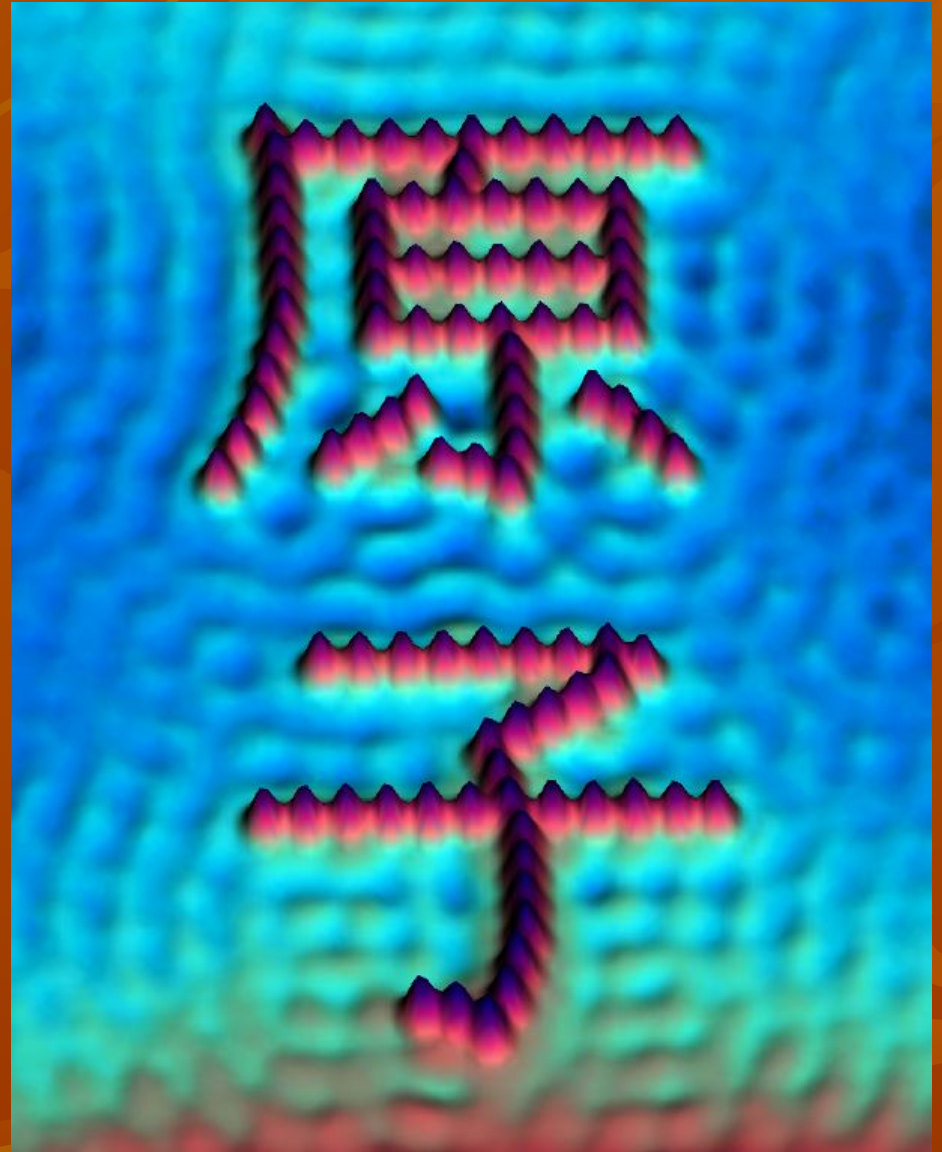
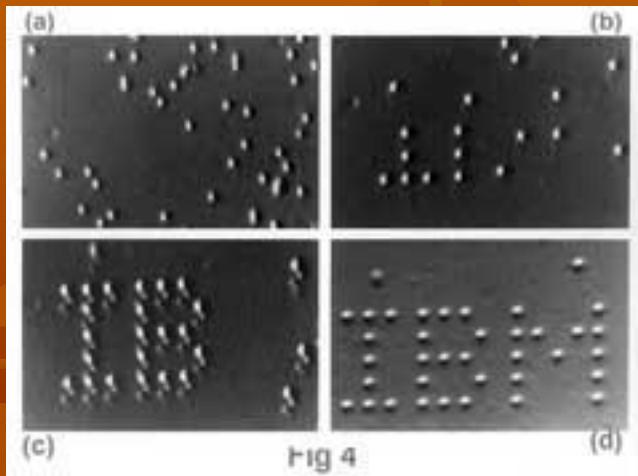


Атомно-молекулярный дизайн

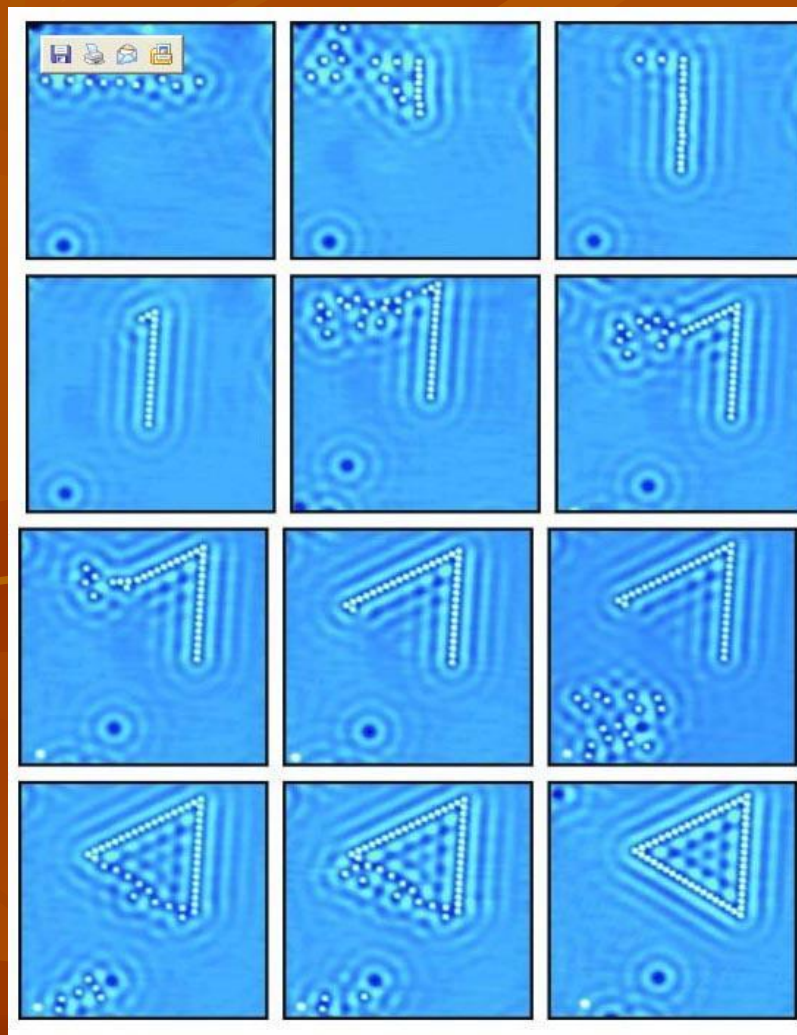
Смещение атомов по поверхности



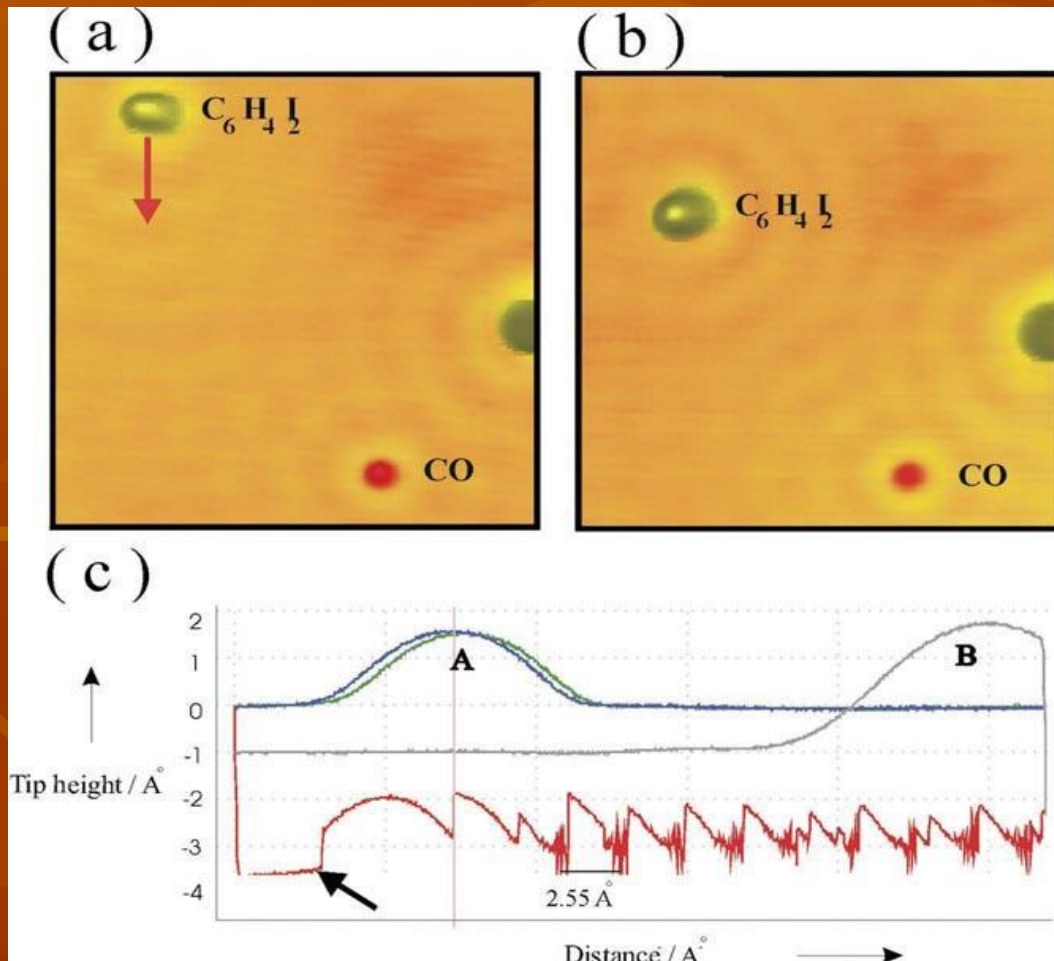
Moving atoms one at a time...



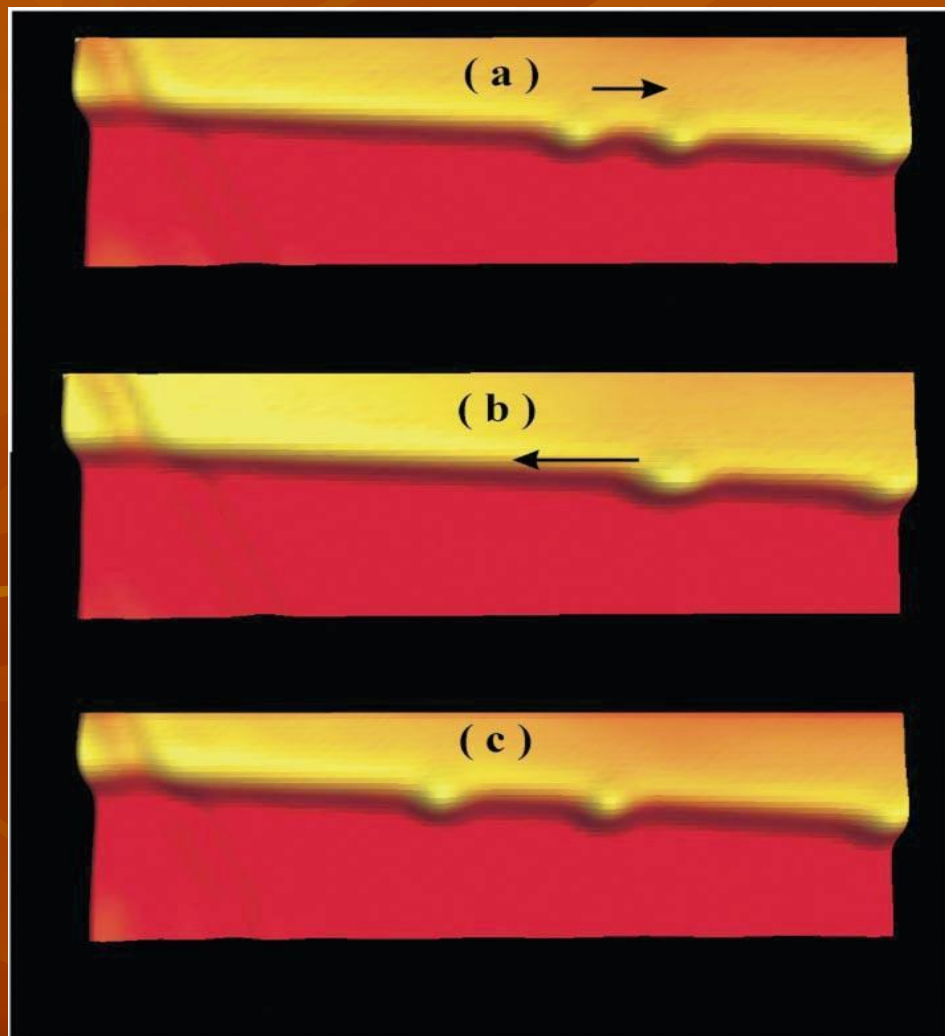
Создание треугольной системы атомов



Смещение молекулы иодбензола



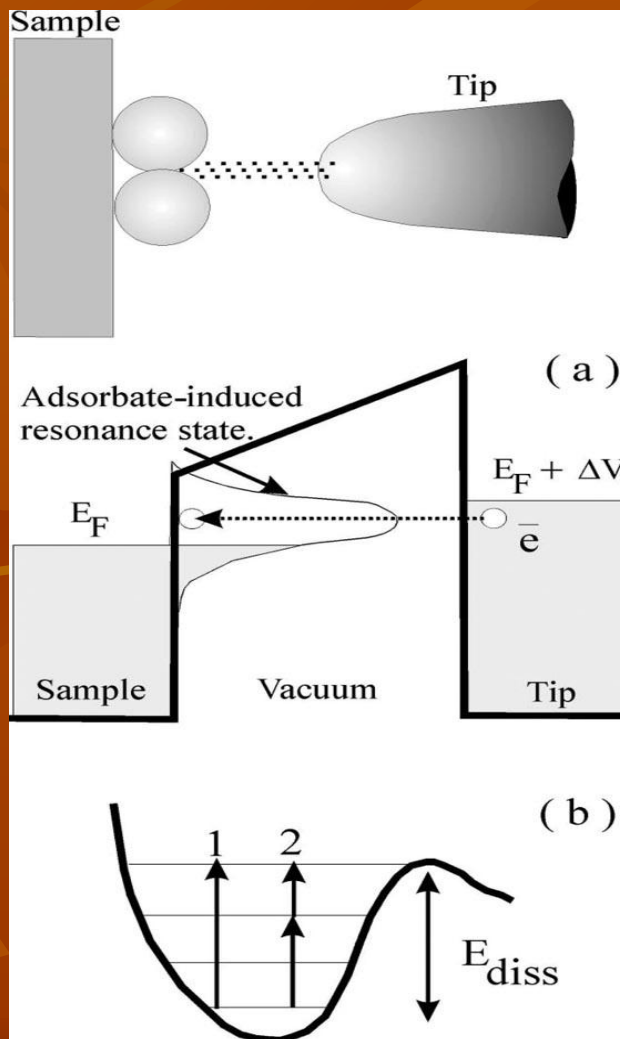
Смещение молекул на поверхности



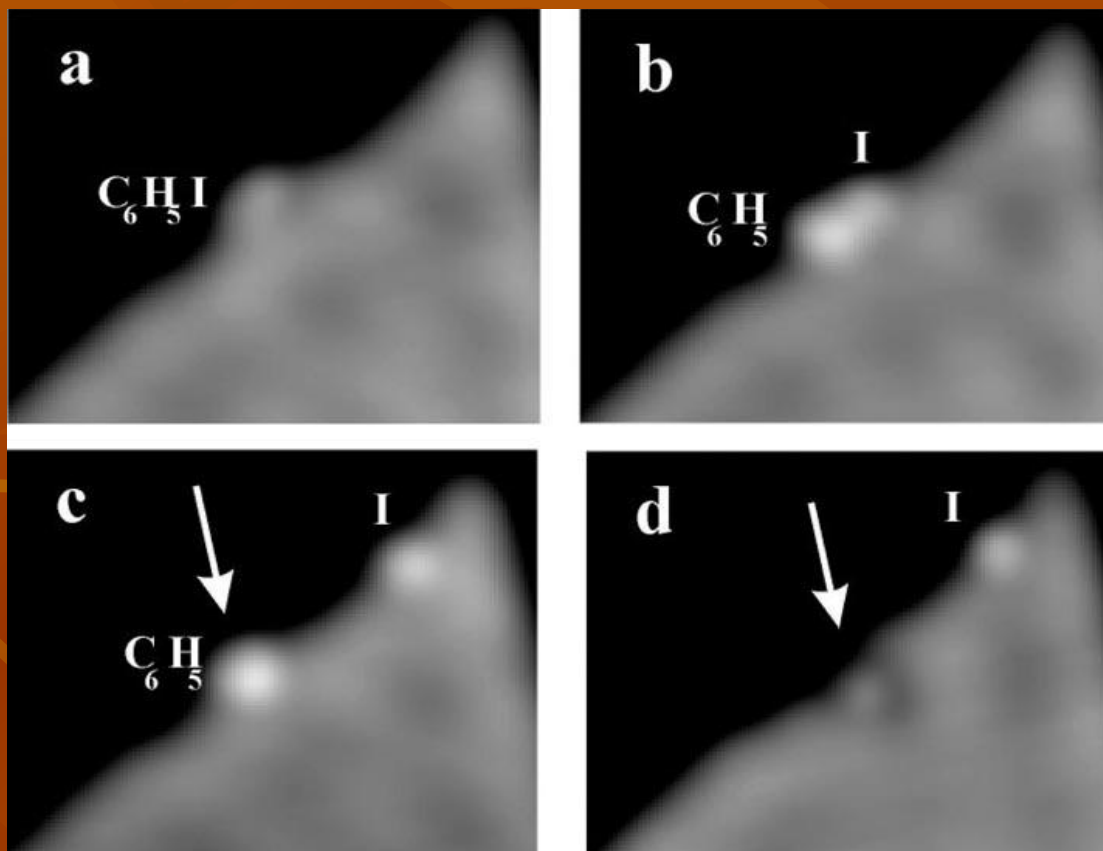


Разложение молекул

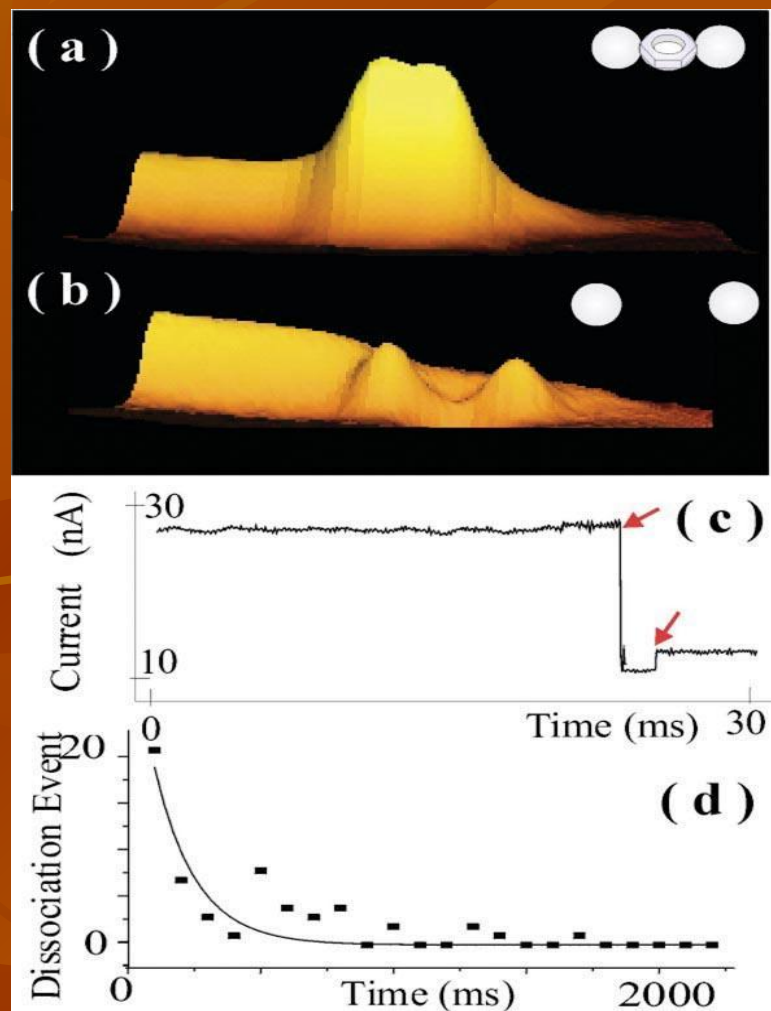
Диссоциация



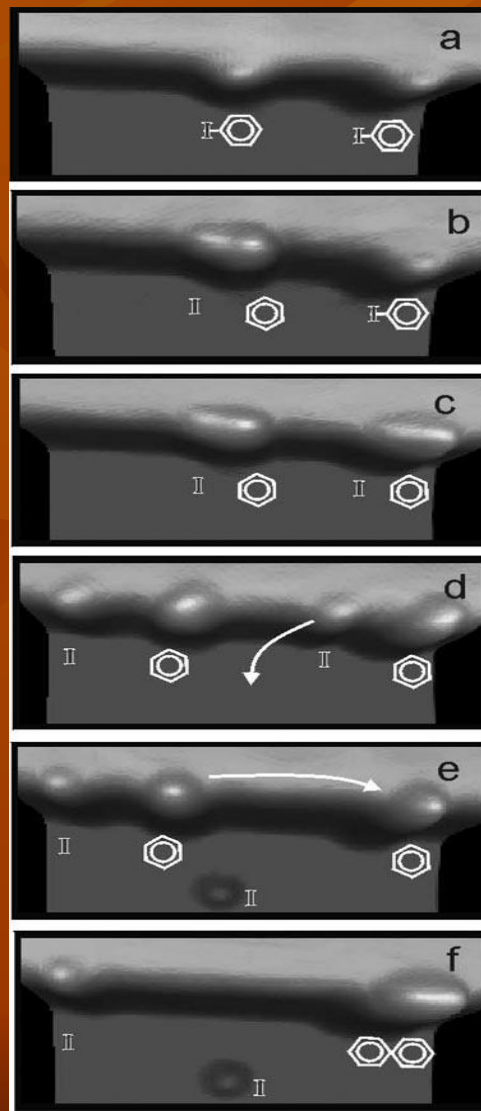
Иодбензол



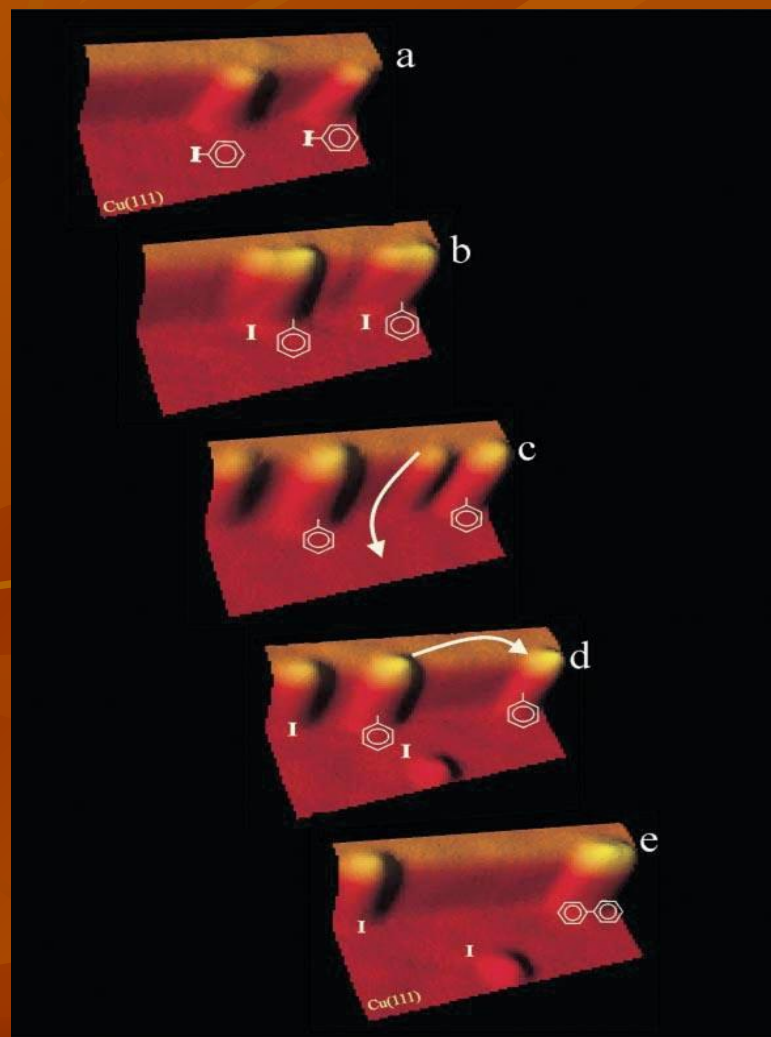
P-диiodобензол



Реакция Ульмана



Реакция Ульмана



Молекулярное конструирование

