Towards surface detection of interference fringes & molecular nanopatterns

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Motivation

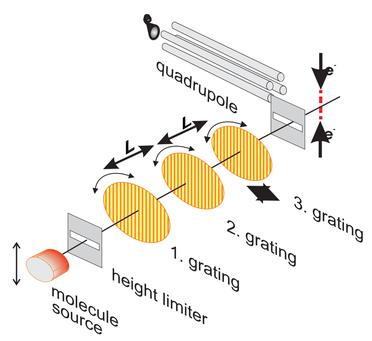
Goal

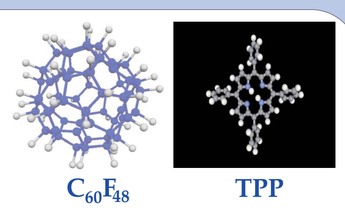
1. Detection of molecular interferograms
2. Molecular nanopatterns

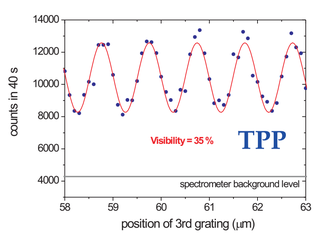
Methods

1. Talbot-Lau Interferometry
2. Fluorescence microscopy
3. Scanning Probe Microscopy

Molecule Interferometry



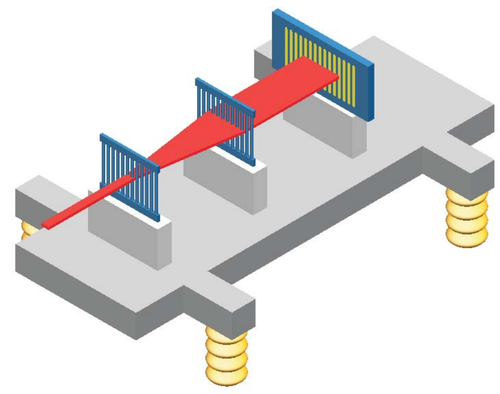




Phys. Rev. Lett. 88, 100404 (2002)

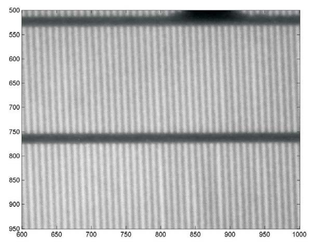
Phys. Rev. Lett. 91, _90408 (2003)

Surface deposition of molecular nanopatterns



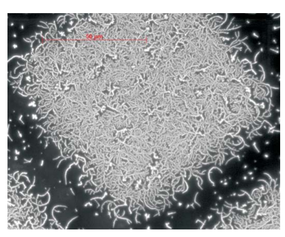
Method 1: Fluorescence detection

Porphyrin contact image of a nanostructure



d=500 nm, g = 1 µm

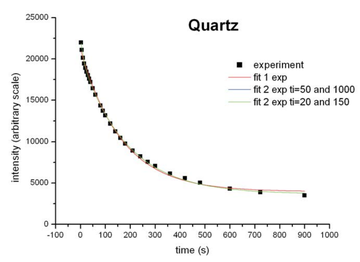
Selforganization @ high molecular coverage



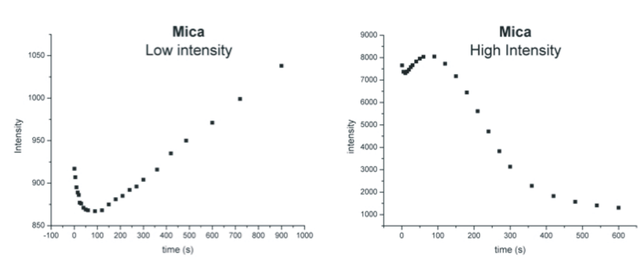
g = 7 µm

Challenge 1: Photo bleaching

Bi-exponential decay on quartz

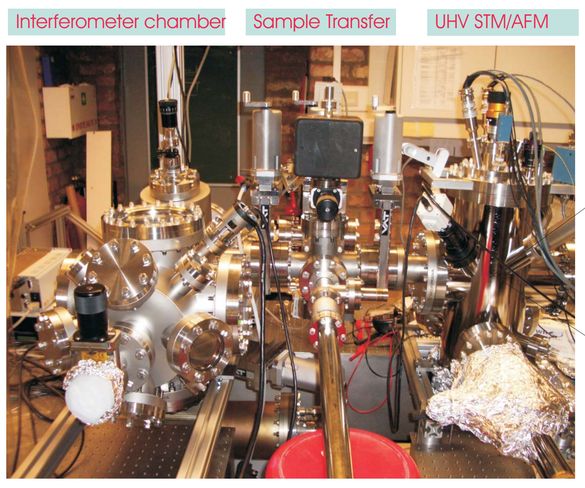


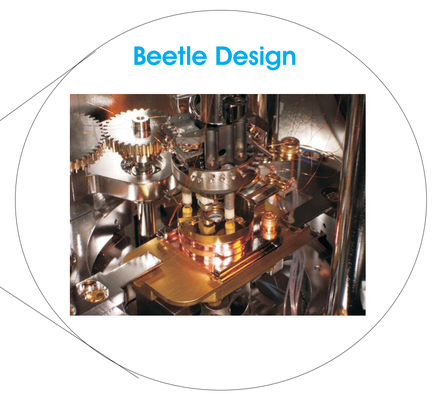
"Photo-recovery" on Mica



Limited interaction time but still high integrated signal

Method 2: VT-UHV-STM/AFM
RHK UHV 700/750





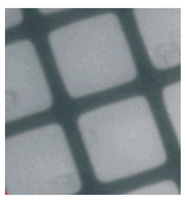
Design properties

1. UHV system with spring suspension and eddy current damping
   - Maintains clean surfaces from deposition to recording
   - Permits preparation of strongly binding surfaces (e.g. Si 111, 7x7)
   - Best possible imaging stability
2. Atomic resolution
   - Finds location of single molecules ('single molecule' interference)
3. Low temperature option (< 30 K)
   - Minimizes mobility for stable molecular patterns
   - Potentially important for further 'on-surface' quantum experiments
4. STM with 5kHz @ 1pA as well as cantilever AFM (all modes!)
   -'Fast' and sensitive detection also of biomolecules and nanocrystals
5. Lithography option
   - Post-processing of molecular nanodeposits
6. Tunneling Spectroscopy
   - Identification of molecular species and novel material properties

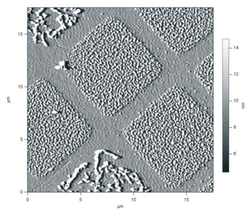
Challenge 2: Surface mobility

d=7 µm, g = 8 µm

Fluorescence



AFM in air



Deposition: Univ. Wien, AFM: Gebeshuber/Aumayr, TU Wien

Preliminary results with TPP on quartz

1) shadow imaging of mask with 2 µm period
2) clear fluorescence pattern still hours after deposition
3) bleaching present but not a limiting factor
4) detection of << 0.1 molecular monolayers

Challenges for interferometry:

1) 1 µm period (300 nm limit in fluorescence)
3) mobility must be further suppressed in order not to degrade the interference contrast

The resolution limit in nanoscale structure can be resolved by SPM methods

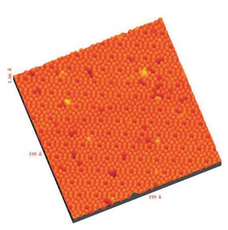
Prospects and proposals

A) Immobilization methods

1) Designed surfaces, proposed are
   a) Reconstructed Silicon111 (7x7): requires UHV
   b) Fullerene Nanosphere as a substrate for fluorescence methods
   c) SAM substrates
   d) Ion bombardment to fabricate surfaces with "nanocraters".
   e) porous alumina

2) Low temperatures

B) High-precision ultra-compact interferometer being built



Si 111 (7x7) (RHK)