

topography

spectroscopy

magnetism

transport

chemistry

ferroelectricity

piezoelectricity

manipulation



**Center for Nanophase
Materials Sciences**

CNMS Instruments for SPM

Two New Requisitions Last Week:

Nanoman V-Advanced AFM

Cryogenic 4-probe STM

Existing facilities:

SEMPA

VT AFM/STM

SAM, LEED, AES/XPS

MBE/ BLAG

Available capabilities soon:

High-field low-temperature STM

Spin-polarized 4-probe STM



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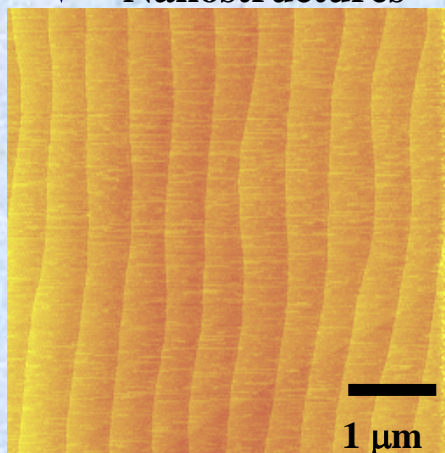


Topography

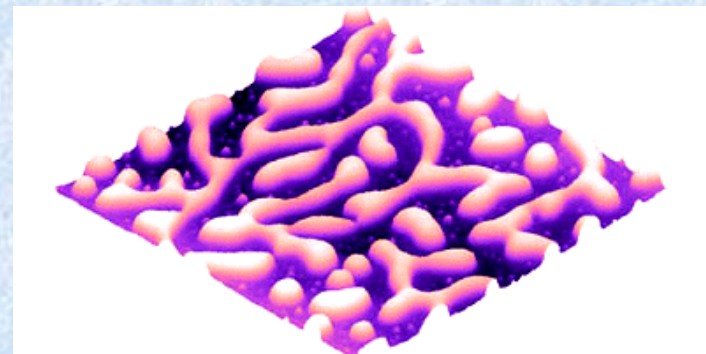
Atomic Force Microscopy

Scientific Drivers

- ★ Structural characterization
- ★ Film growth
- ★ Nanostructures

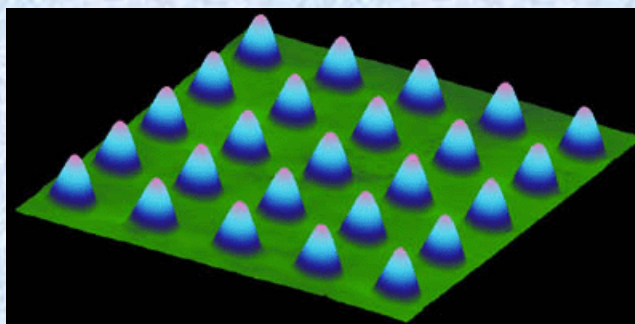


SrTiO₃



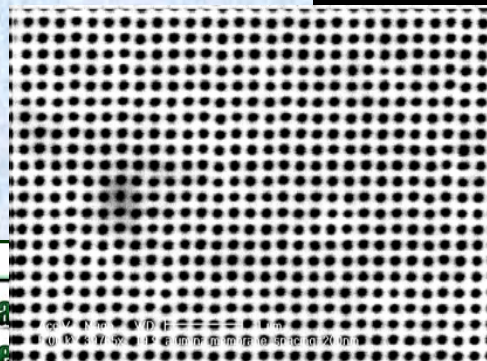
Polymer blend

C. Ton-That
Robert Gordon Univ



SiN/Si features

L. Folks, IBM



porous alumina

Capabilities

- ★ Simple sample handling
- ★ Large scan range
100x100x20 μm
- ★ Topographic analysis



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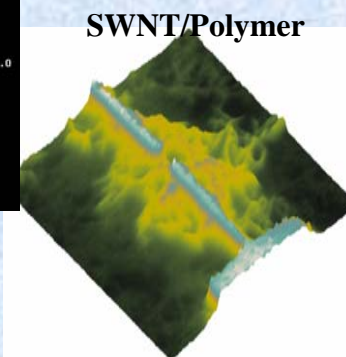
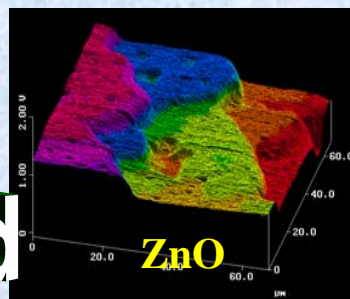
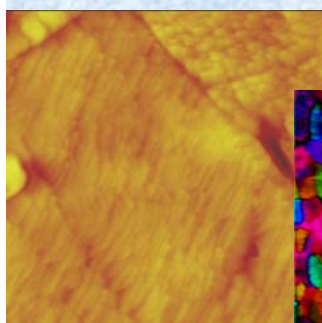
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Ferroelectricity, Magnetism, Piezoelectricity, Transport

Advanced Scanning Force Microscopy

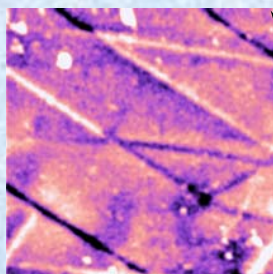
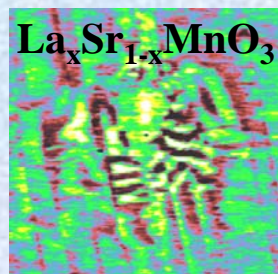
Scientific Drivers

- ★ Imaging of physical properties
- ★ Conductivity
- ★ Ferromagnetism
- ★ Ferroelectricity
- ★ Catalysis



Piezoresponsive
Force Microscopy

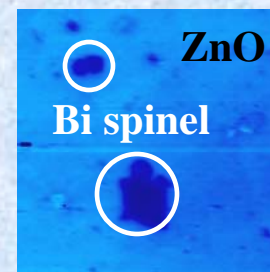
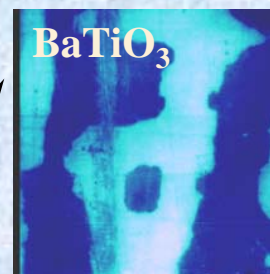
Transport



Magnetic Force Microscopy



Veeco Nanoman V



Potential imaging

First one in the world

More development on the way



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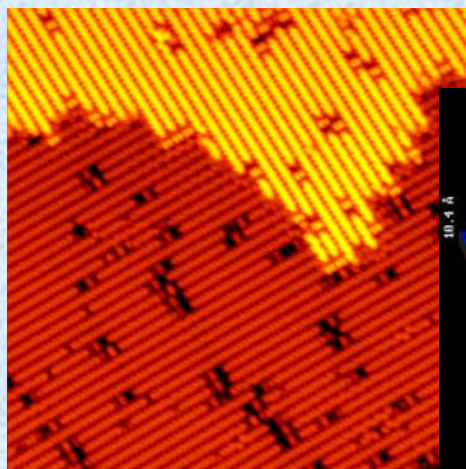
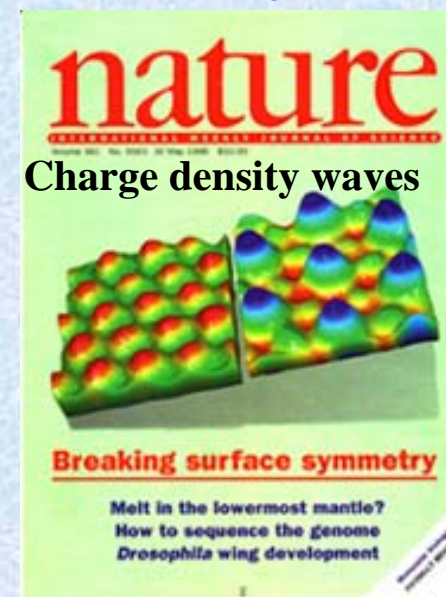
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Electronic Structure

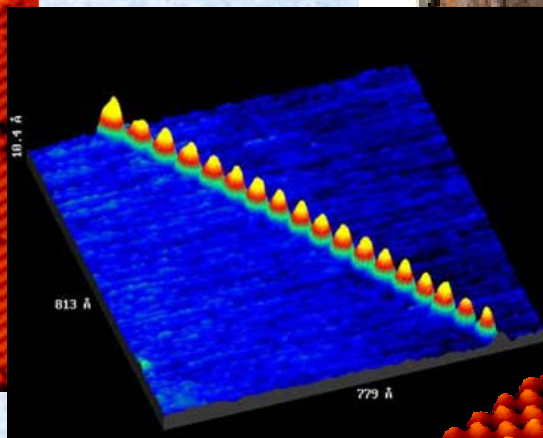
Scanning Tunneling Microscopy

Scientific Drivers

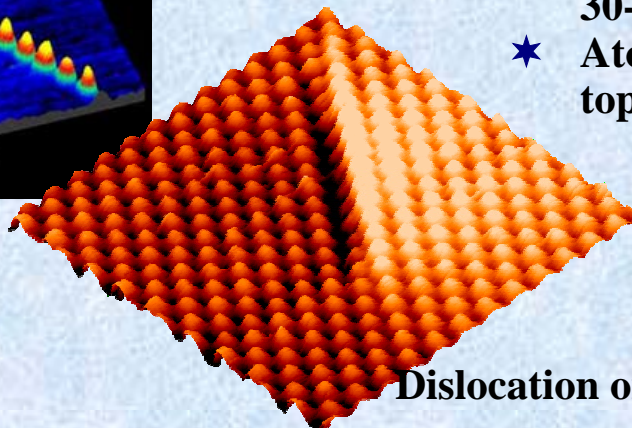
- ★ Structural characterization at atomic scale
- ★ Electronic structures in reduced dimensionality
- ★ Electronic reconstructions



Si (100)



Atom chain



Dislocation on Ag (100)

Capabilities

- ★ Variable temperature
30-400 K
- ★ Atomic resolution
topographic analysis



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Transport with 4-Probe STM

4 probe STM with SEM/SAM

Scientific Drivers

- ★ Nanoscale electrical transport
- ★ Nanofabrication and manipulation
- ★ Elemental identification

Chamber

Chamber

True low-T 4-probe STM

Capabilities

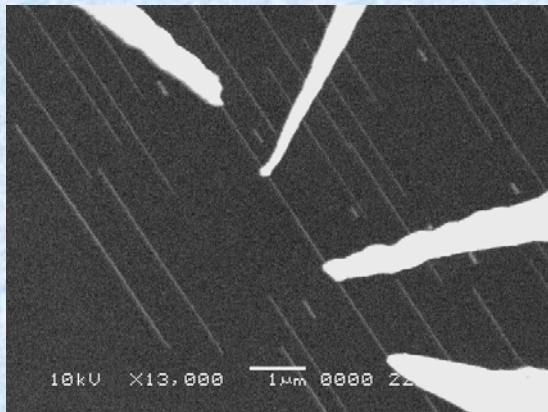
Four probe STM

- ★ Independent operation 10-500 K
- ★ Molecular-Beam Epitaxy
- ★ In-situ sample preparation
- ★ Scanning Electron Microscopy
View the four tips, Electron beam induced current
- ★ Scanning Auger Microscopy
Map the chemical composition

Unisoku

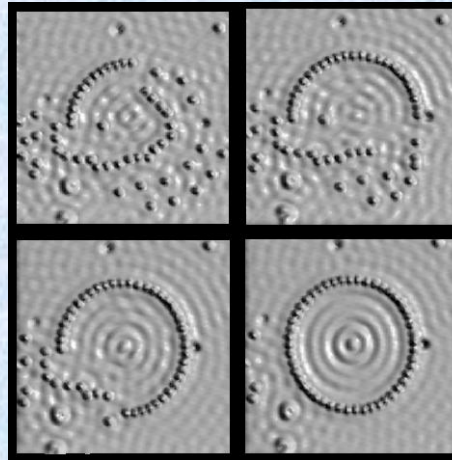


Transport in Low-dimensional Materials



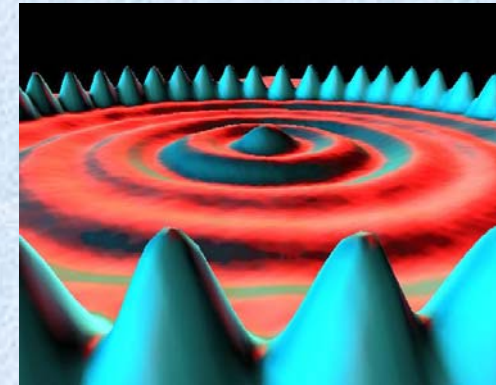
Co Silicide Nanowires on Si(110)

H. Okino, APL **86**, 233108.



Quantum corral of 48 iron atoms on copper surface positioned one at a time with an STM tip.

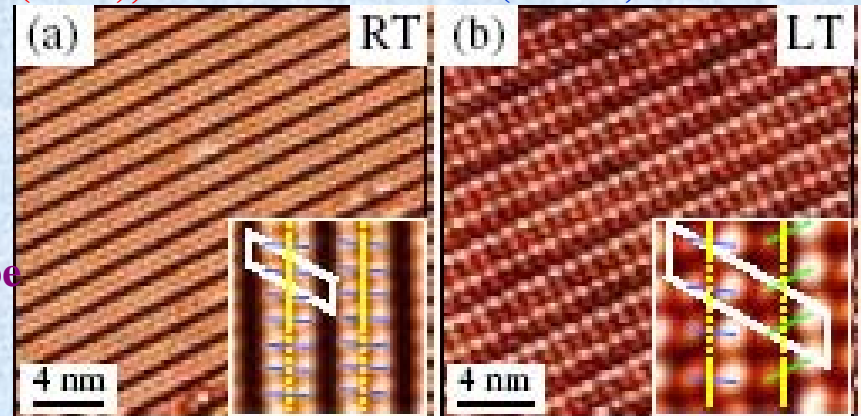
Corral diameter 14 nm, M. Paniccia, IBM



In/Si(111) atomic chains

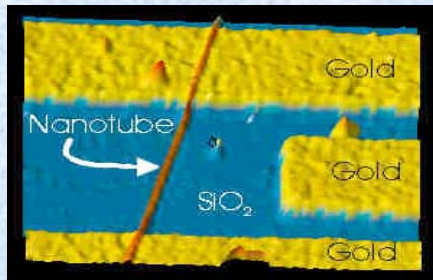
Metallic Phase
(4 × 1), RT

CDW Phase
(8 × '2')



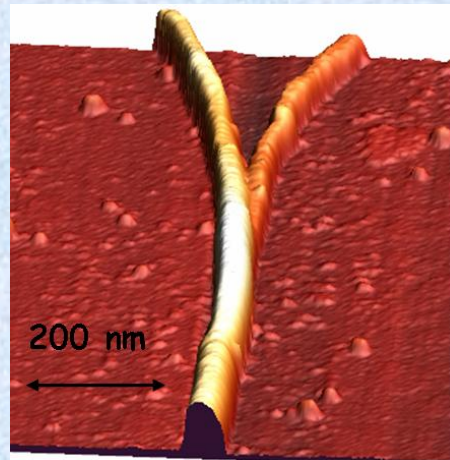
PRL95, 046102 (2005)

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Nanoelectronics

Ph. Avouris, IBM



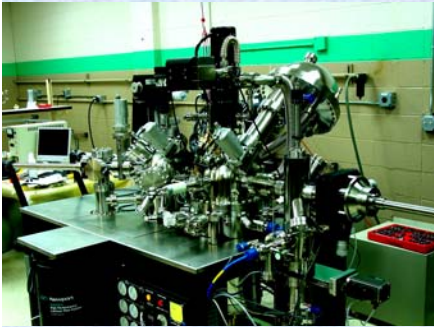
Y-junction carbon nanotube

Rao, Clemson University

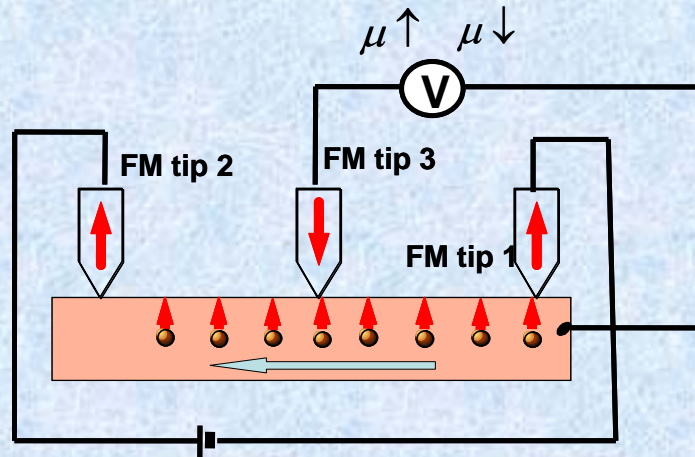


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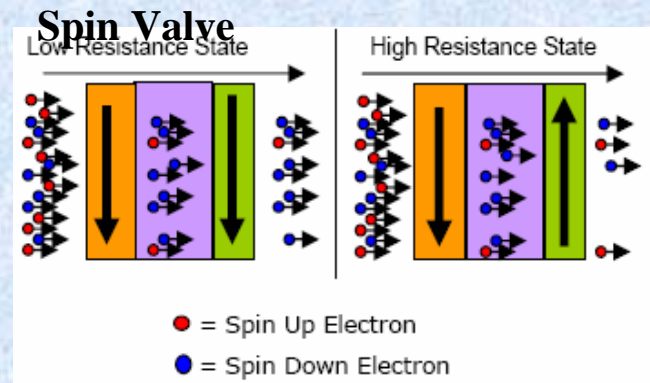
Spin-sensitive Imaging for Spintronics



Spin transport imaging: multiple probe SP-STM

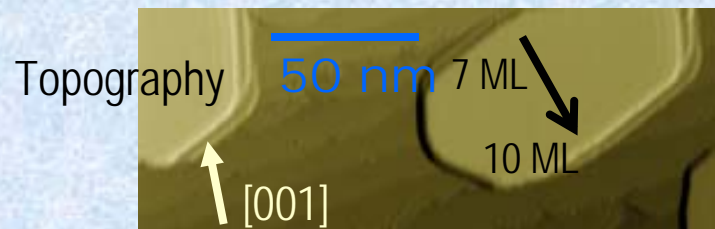
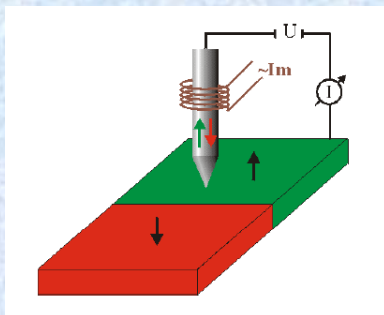


- ★ Spin injection across interface
- ★ Spin polarization detection
- ★ Spin coherence and transport

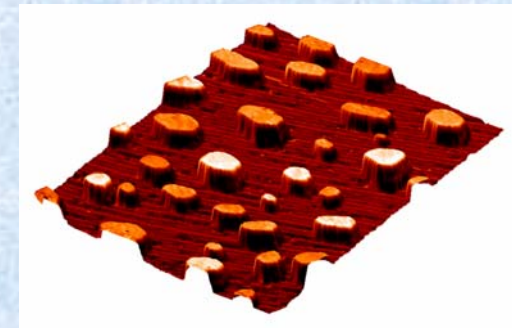
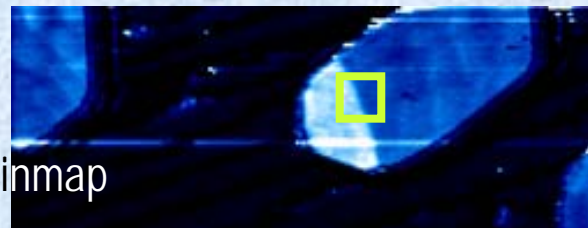


Magnetic domain imaging: single tip SP-STM

US Patent, pending



Domainmap

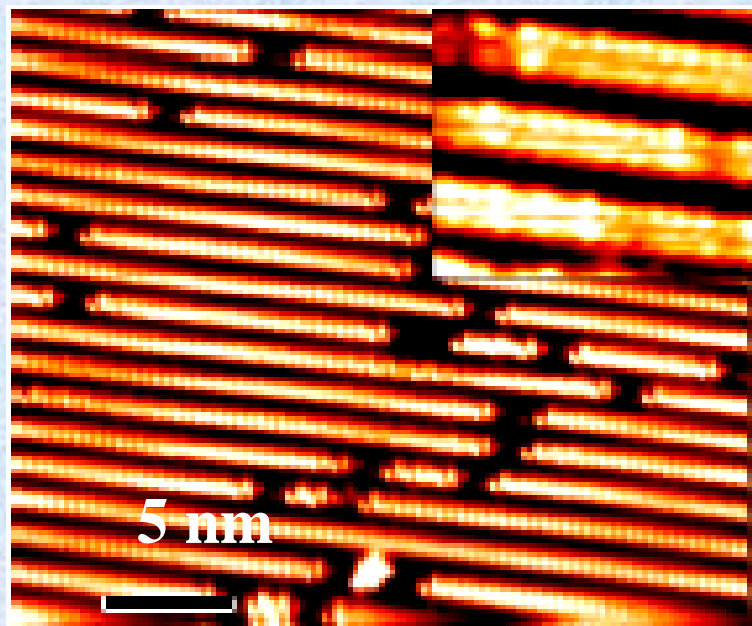


Magnetic domains in Fe islands on W(110)



Single Molecule Spectroscopy

Low Temperature, High Field STM

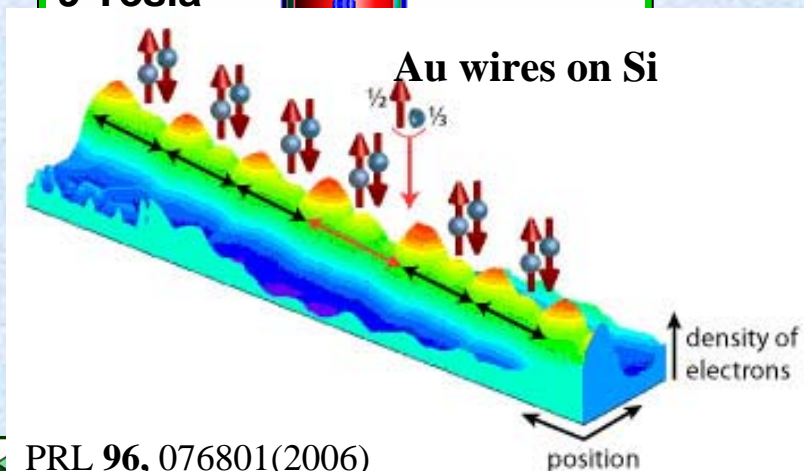


Scientific Drivers

- ★ Single molecule spectroscopy
- ★ Atomically-resolved spectroscopy maps
- ★ Quantum response at low T
- ★ Domain resolution in high magnetic field

Capabilities

- ★ Scanning Tunneling Microscopy
 - Low T - 300 mK
 - High B - 9 Tesla
 - STM rotates in magnetic field
 - Optical access to sample
 - Extreme stability
- ★ Sample preparation
 - Cryogenic UHV cleaving
 - Sample exchange from RT

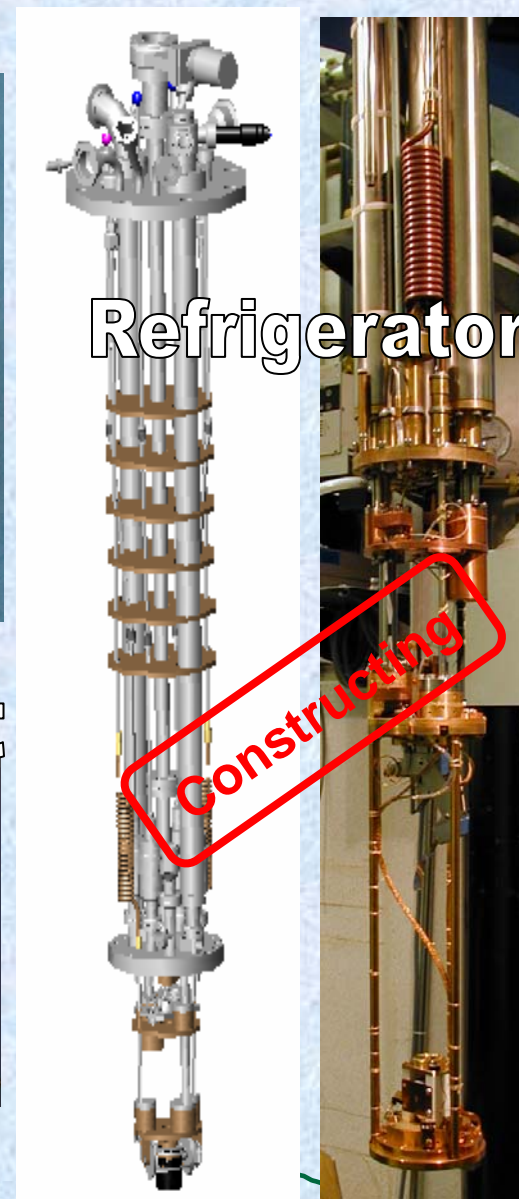
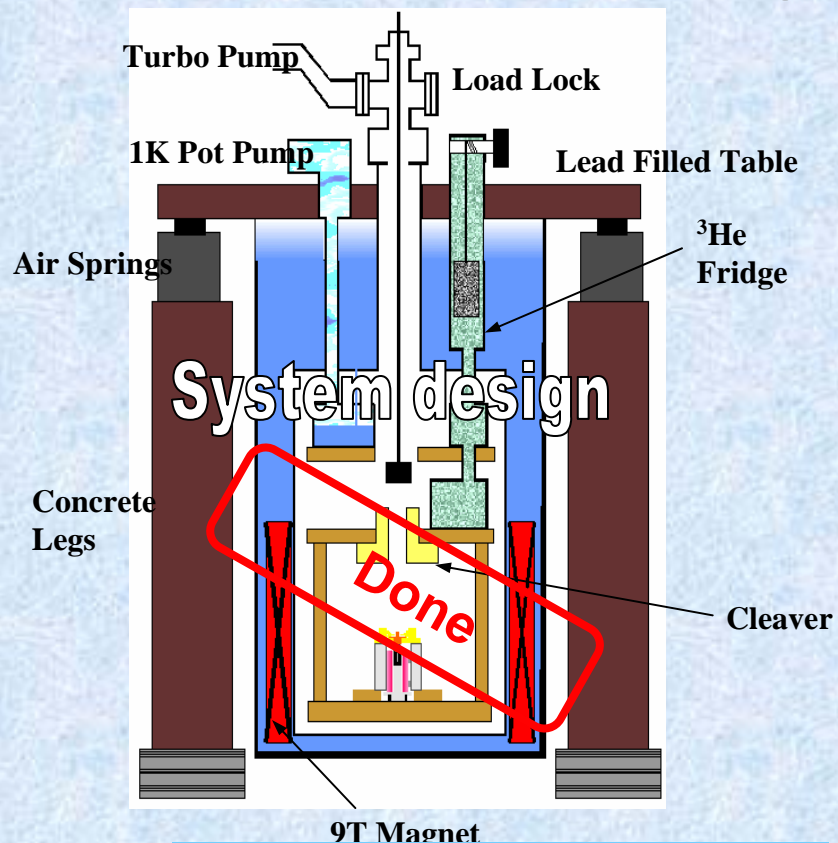


PRL 96, 076801(2006)

Fractional quantum numbers in a phase slip

❖ LT-HF STM

The Instrument (6/14/06)

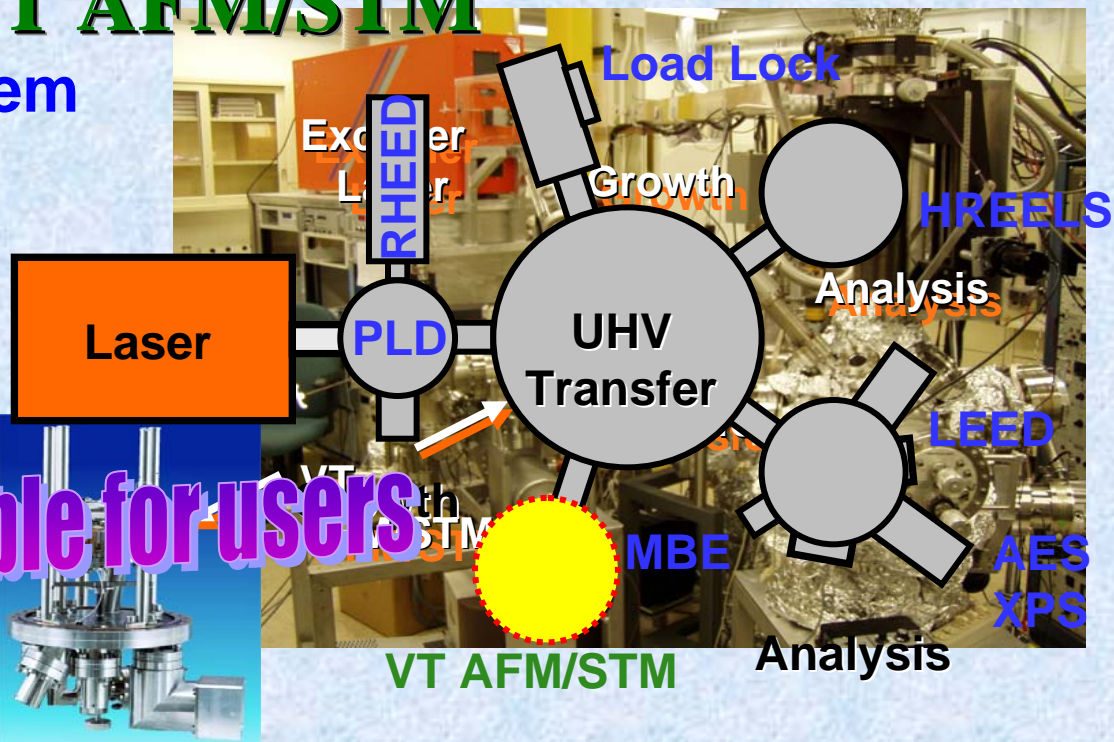


UHV Growth & VT AFM/STM NanoTransport System

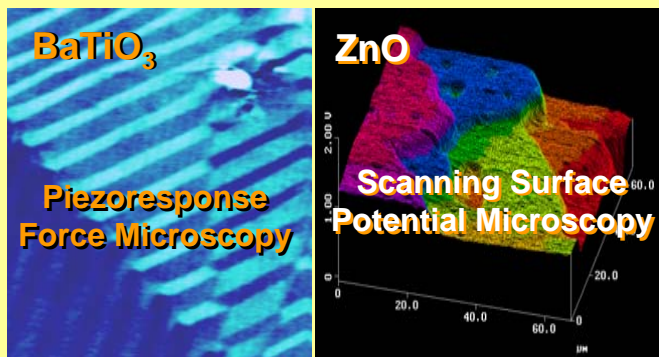
Scientific Drivers

- ★ Synthesis and characterization without exposure to atmosphere
- ★ Oxide films
- ★ Cryogenic imaging

only one available for users



Oxides growth and characterization



Capabilities

- ★ Pulsed Laser Deposition
 - High pressure ozone for oxide synthesis
 - High pressure RHEED during growth
 - 1175 K, 1000 mTorr
- ★ MBE Deposition
- ★ Scanning Probe Microscopy
 - Atomic resolution AFM, STM
 - 20-400 K
- ★ Surface Characterization
 - LEED, AES, XPS, HREELS
 - 20-1000 K



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**Come to
talk to us**

Ward Plummer



John Wendelken



Art Baddorf



Hanno Weitering



Minghu Pan



Zheng Gai



**Jian
Shen**

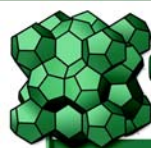
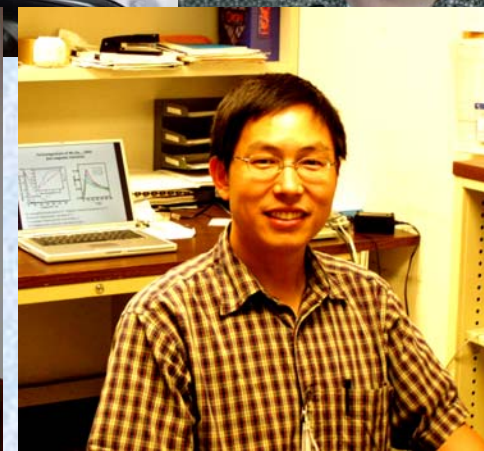


**Sergei
Kalinin**



TaeHwan Kim

**AnPing
Li**



**Cent
Ma**

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