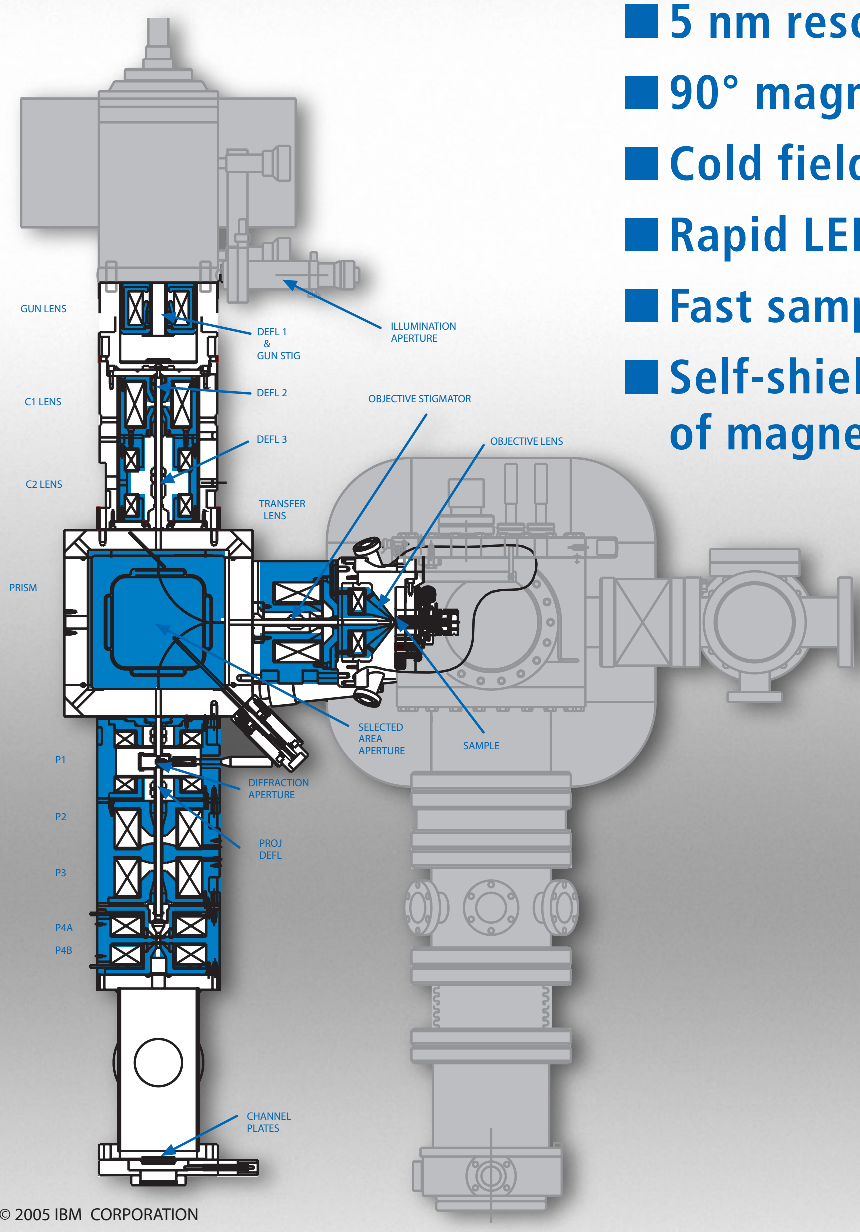
COMPONENTS FOR SURFACE ANALYSIS

Low Energy Electron Microscope

FE-LEEM P90

- **5 nm resolution**
- **90° magnetic deflector**
- **Cold field emitter**
- **Rapid LEED/LEEM switching**
- **Fast sample exchange**
- **Self-shielding design of magnetic lenses**



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LEEM System Concept

Principle of operation

Electrons from a cold field emitter source are imaged through the condenser stage.

The prism array, a 90° deflector, refocuses the beam onto the back focal plane of the rotation-free objective lens doublet. The prism array consists of a central square magnetic field surrounded by four smaller regions where the field is a factor of three larger. It results in distortion-free, achromatic images and LEED patterns.

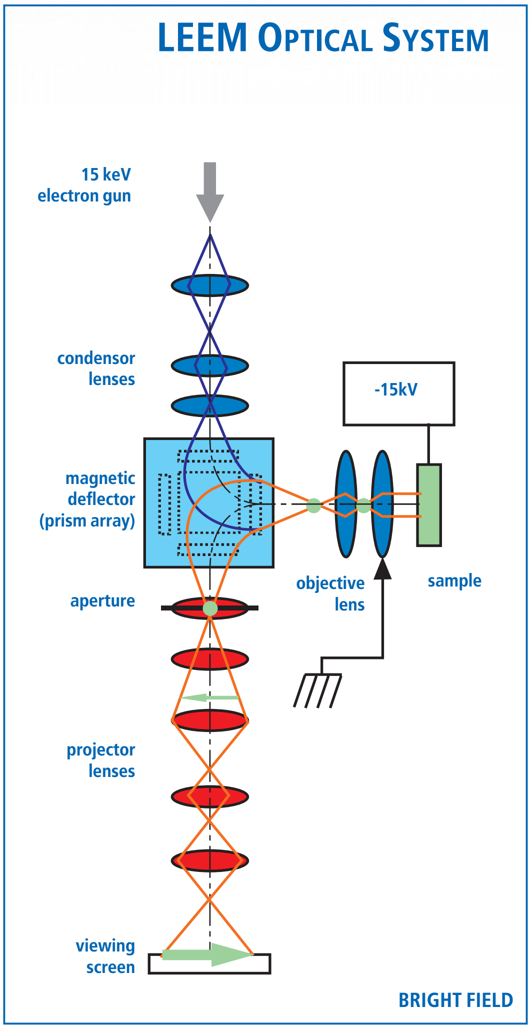
The objective lens doublet transfers the beam onto the sample, the diffraction pattern to the back focal plane of the objective lens doublet and the image of the sample from the region within the lens doublet back to the prism array where it is located on the diagonal of the prism array.

The prism array deflects the electrons 90° downward into a system of projector lenses. A contrast aperture can be placed for dark-field measurements.

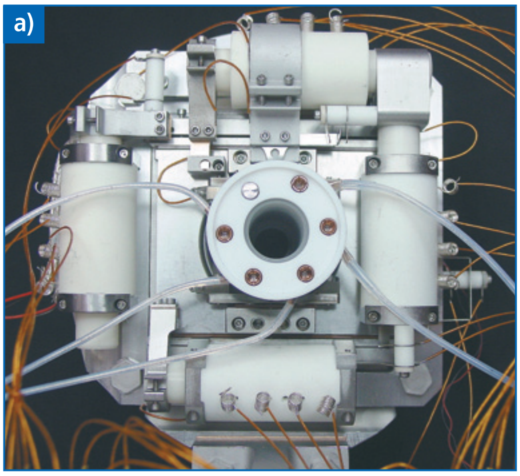
Two stigmators (gun and objective) correct for astigmatism. Four beam steering coils align the system.

The magnification range is 200-120,000 x.

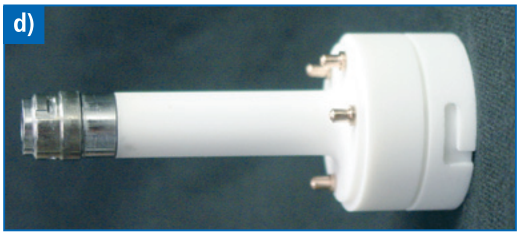
Low Energy Electron Microscopy, invented by E. Bauer, has developed into one of the premier techniques for in situ studies of surface dynamical processes, growth and structure.
Now, the next generation instrument design by Rudolf Tromp becomes commercially available[1),2)].



It takes into account the main concerns of surface scientists and microscopists: application-orientation, simplicity, ease of operation, robustness and superior resolution.
A large number of major publications prove the mature design of the instrument.
The magnetic column is self-shielding similar to high resolution TEMs and SEMs.
The 90° magnetic deflector enables distortion free achromatic images and LEED patterns.
The sample holder, transfer and storage system are designed for rapid pump down to facilitate a fast turnaround (typically 3 Si-samples/day to UHV).
The robust, low maintenance, high reliability pumping system enables imaging with running turbo pump for gas load experiments.
The extremely compact, low-vibration stage with in-vacuum actuators for lateral and tilt sample motion allows space for an optional piezo-stage for automatic drift compensation by software controlled feature tracking.
The system can be combined with an array of further deposition and analysis chambers (e.g. XPS, STM, MBE).

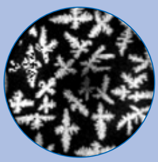


a) 5 axis stage
b) objective lens
c) sample cap
d) sample holder



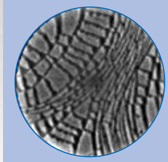
Applications

PEEM



Photoelectron emission microscopy. Electrons are excited with a UV light source. The contrast is based on work function differences on the sample. The photoelectron angular distribution is visible in the intermediate image plane.

MEM

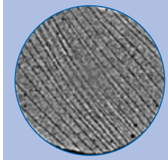


Mirror electron microscopy. The electron energy is reduced to where the electrons return in the retarding field, before they hit the sample surface. The contrast mechanism is based on local changes in the retarding field on the sample surface, such as steps and grains.

Dark field imaging

Usage of one LEED spot in the intermediate plane for imaging. All areas on the surface that contribute to the existence of this spot appear bright in the image, all other areas appear dark.

Phase contrast

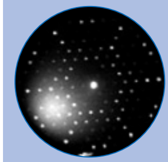


Usage of the wave nature of the incident electron beam to generate a vertical diffraction contrast, e.g. to make steps visible on the surface.

Reflectivity contrast

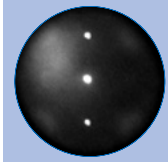
Different areas on the surface might show a difference in electron reflectivity, depending on the surface material and structure. The reflectivity coefficient depends on the incident electron energy. The most famous example is the difference between the (7x7) reconstruction and the (1x1) structure on the Si(111) surface at ~850°C. At an electron energy of about 10 eV the (7x7) areas appear much brighter than the remaining surface.

LEED

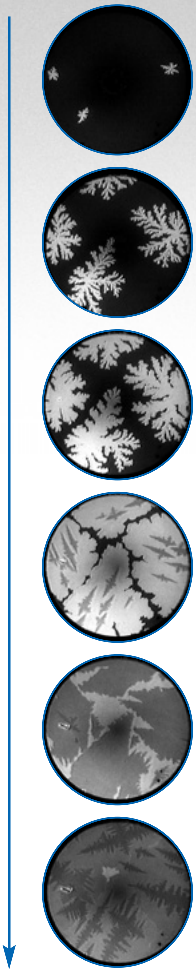


Since a diffraction pattern is formed in the backfocal plane of the objective lens, it is possible to image this pattern on the screen (LEED).

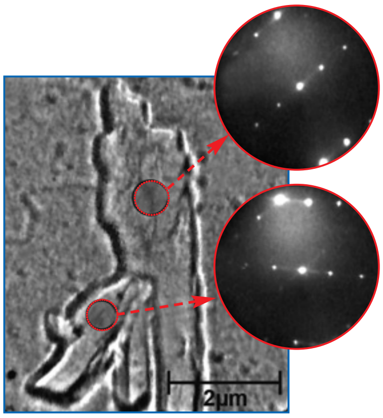
Microdiffraction



By restricting the electron beam to a very small area on the surface (<< 1 µm), it is possible to determine the LEED pattern of small areas on the surface, like the LEED pattern of single islands or terraces in order to determine their crystal structure and orientation.



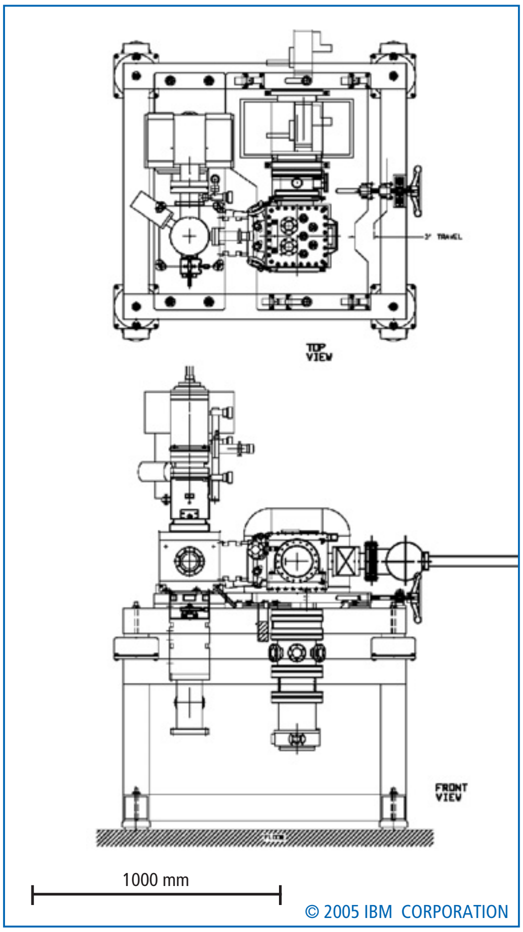
PENTACENE GROWTH AND MICRODIFFRACTION



Images courtesy of IBM 4), 5)

Features

- 5 nm resolution
- 90° magnetic deflector
- Cold field emitter
- Rapid LEED/LEEM switching
- Fast sample exchange
- Self-shielding magnetic lenses
- Clear-cut adjustment of e-beam
- Sample garage with 3 positions
- Objective lens doublet for rotation free images
- Compact 5 axis low drift sample stage with in-vacuum actuators
- Micro-diffraction down to 50 nm
- Continuous imaging at up to 1200°C long term, 1500°C short term
- Optional piezo stage for nm-scale feature tracking
- Pumping system designed for fast pump down, gas load, low maintenance, long term use.
- Base pressure 10^{-10} mbar
- Optional energy filter



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Literature

1) R.M.Tromp, M. Mankos, M.C. Reuter, A.W. Ellis, M. Copel,
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2) R.M.Tromp,
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3) F. M. Ross, R. M. Tromp and M. C. Reuter,
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