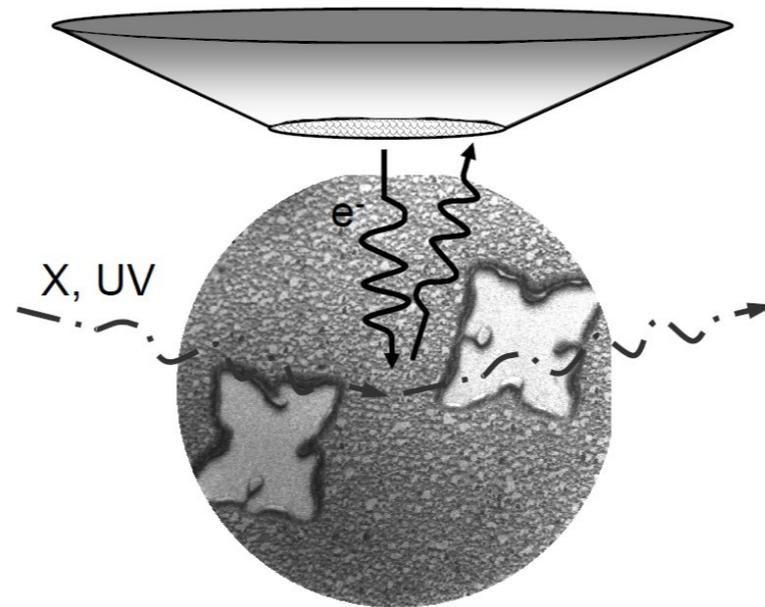


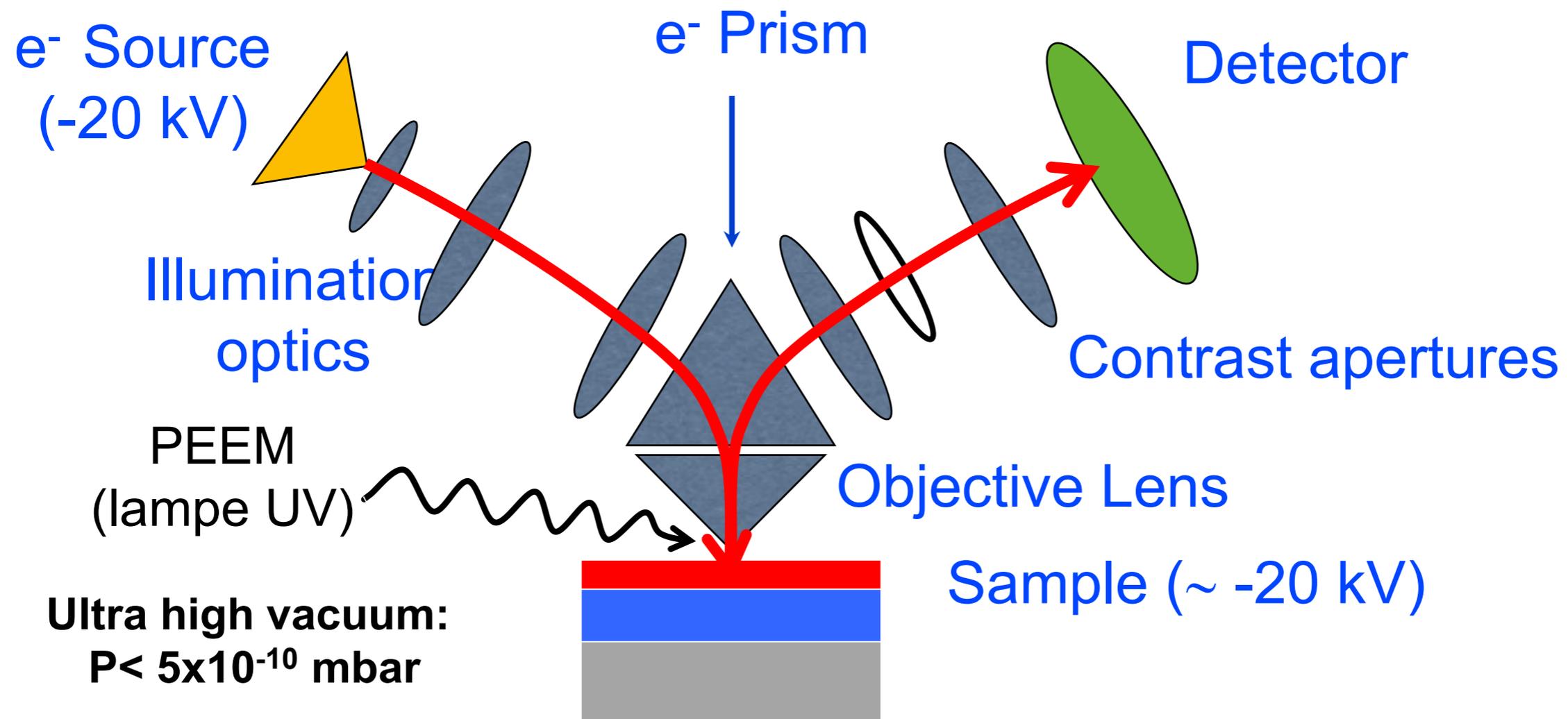
# Structure and surface dynamics of solids with low energy electron microscopy

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# Principle of Low Energy Electron Microscopy (LEEM)

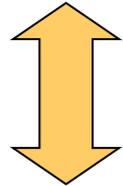


## Main characteristics

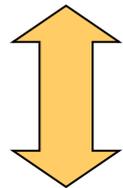
- Energy e<sup>-</sup> < 20 eV
- Reflection/Diffraction → image
- 0.1s/image
- Lateral Resolution: 5 nm
- Vertical Resolution: atomic

# Out-of equilibrium phenomena

Out-of-equilibrium phenomena in crystal growth



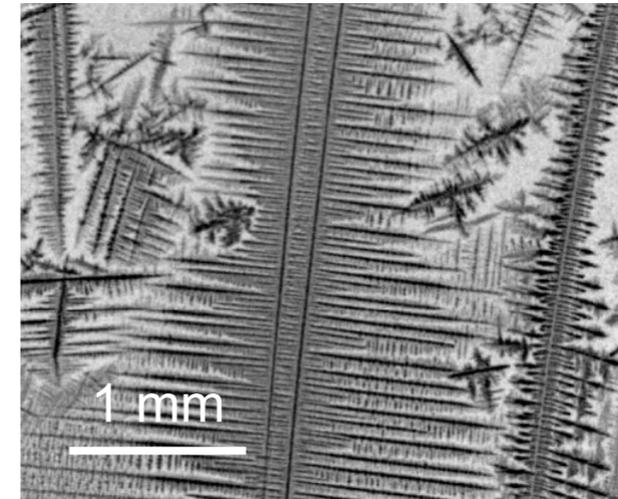
Instability formation



Atomic structure, size, shape, organization

Non-linear physics of morphogenesis

Growth front instabilities: dendrites

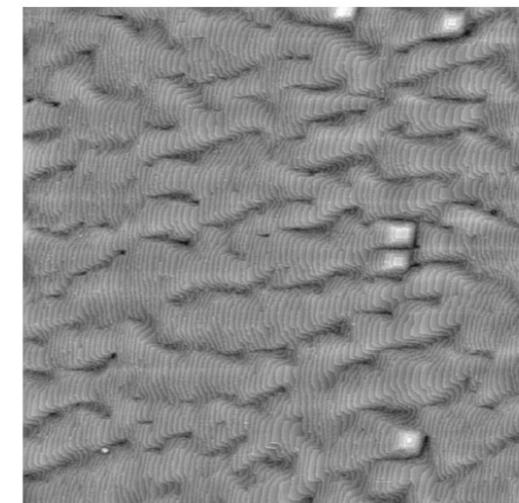


Directed solidification

Alloys Ga-30wt%In  
X-ray Microscopy  
(gradient: 2.5 K/mm)

S. Boden et al. Int. J.  
C. Met. Res. (2009)

Surface instability: meandering



Homoepitaxial growth

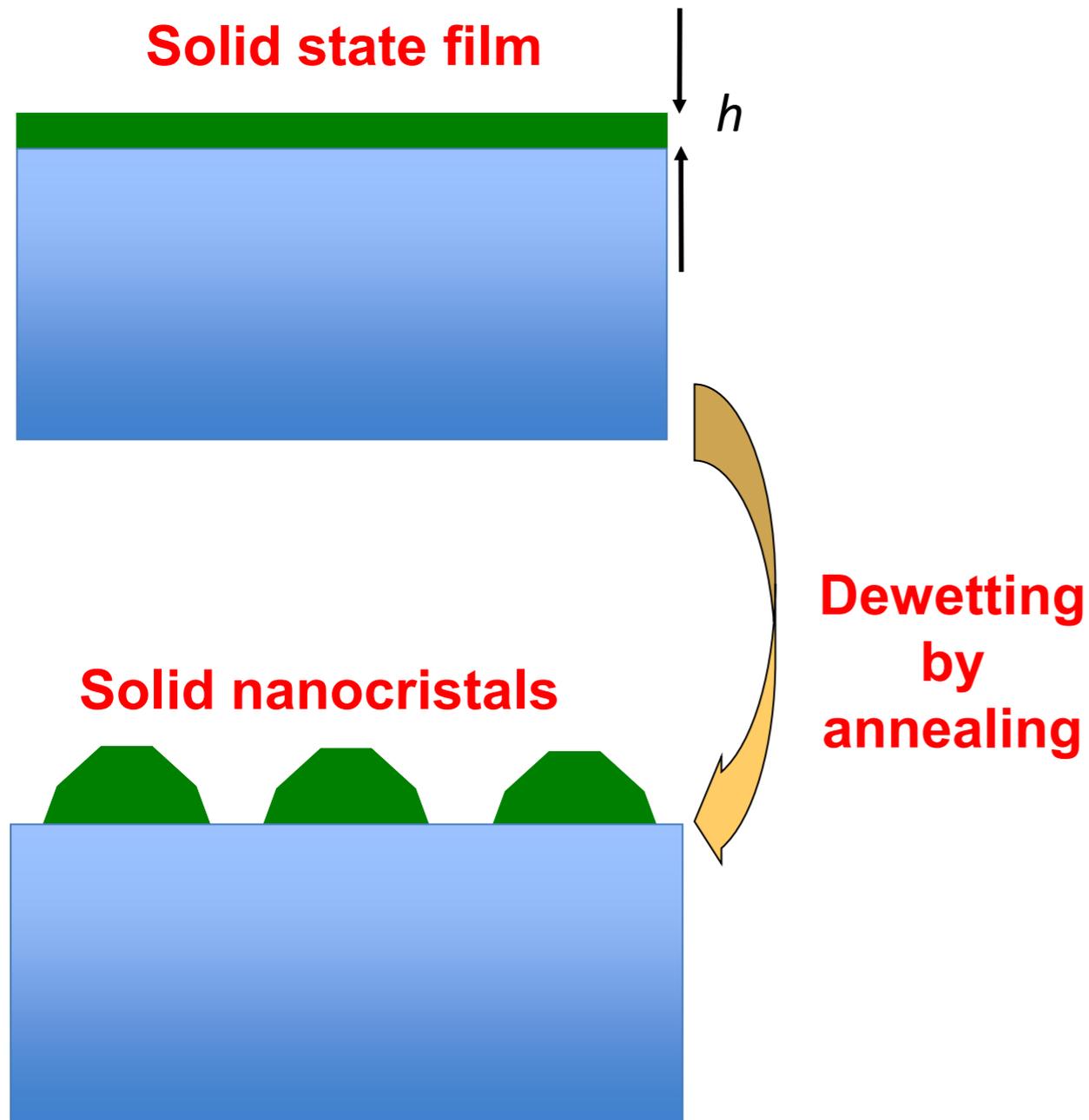
Cu/Cu(1 1 17)  
T=280 K (STM)

T. Maroutian et al.,  
Phys. Rev. B (2003)

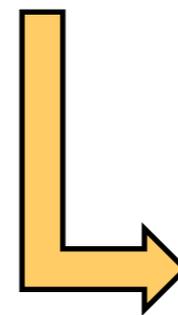
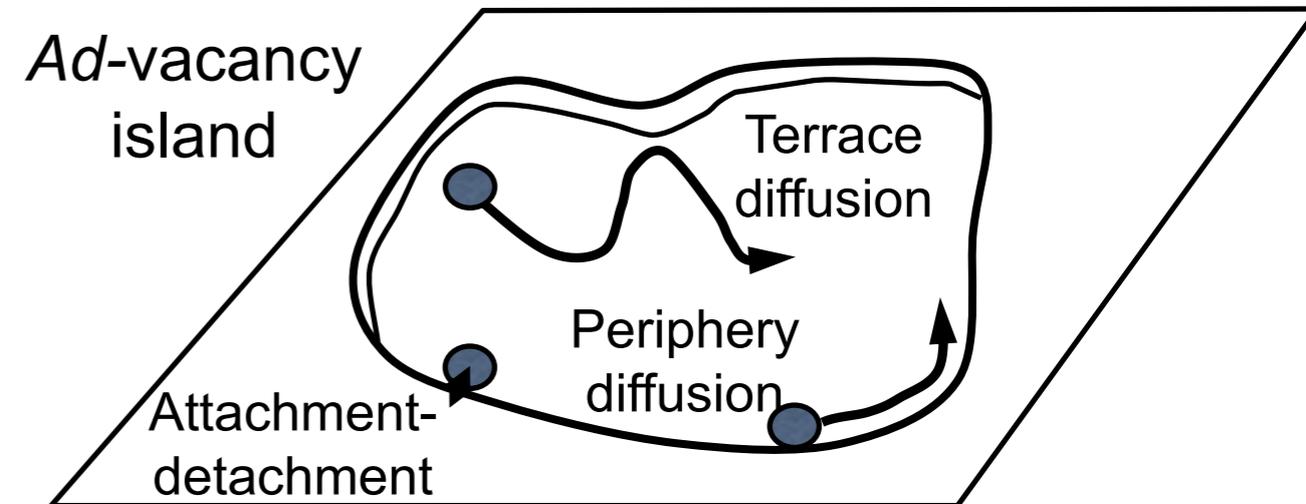
1. Multi-scale approach
2. *in situ* and in real time characterisation

# Surface mass transport

## Solid state dewetting of thin films



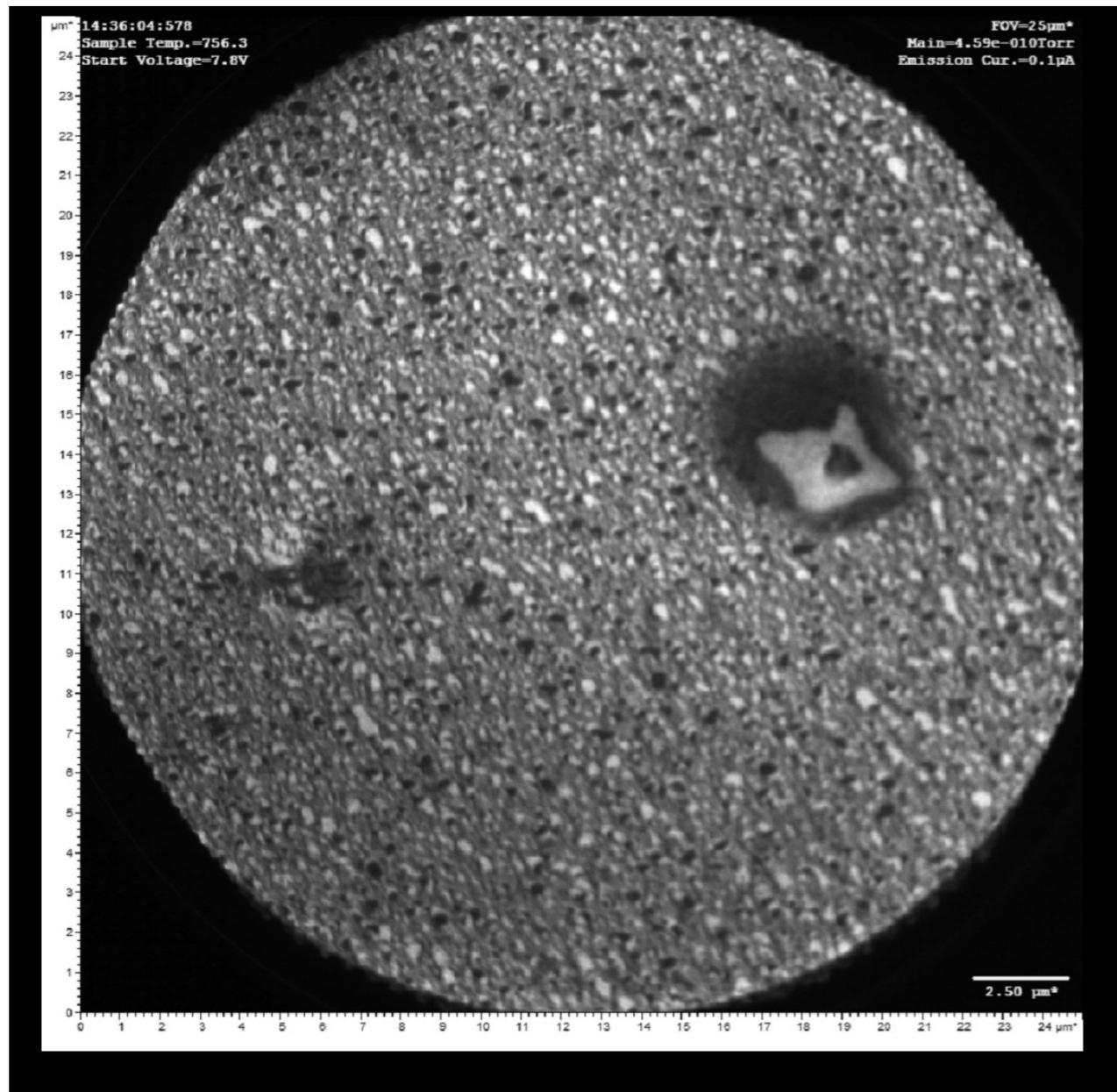
## Surface electromigration



**Biased surface diffusion under an applied electric field**

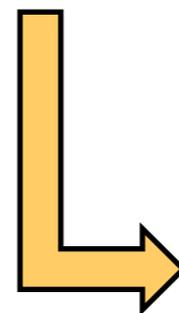
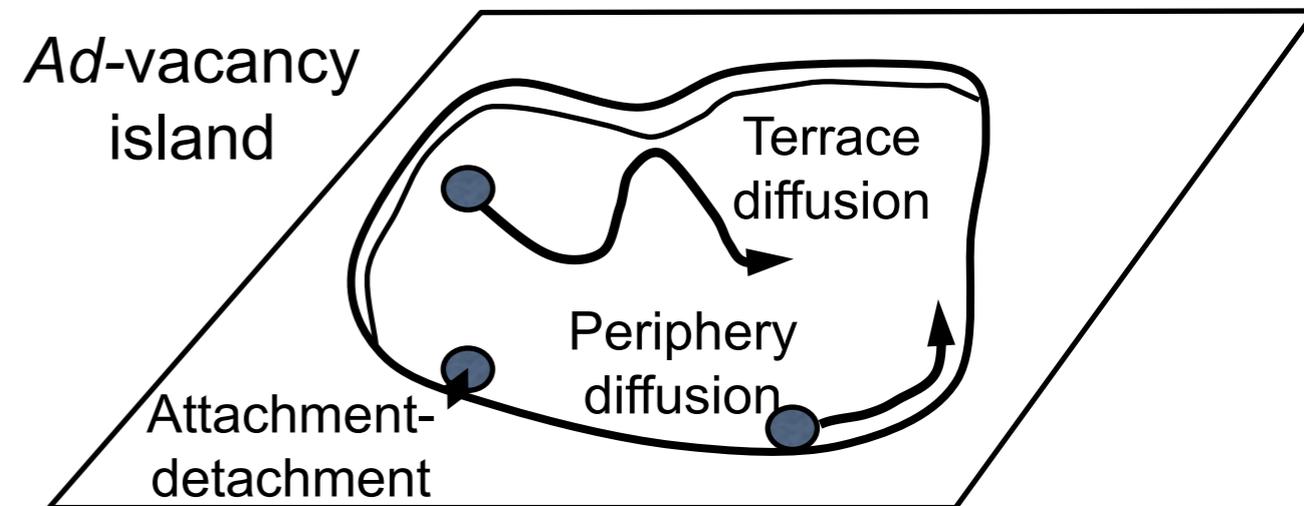
# Surface mass transport

## Solid state dewetting of thin films



22 nm Si(100) on SiO<sub>2</sub> (SOI)  
870°C (42 minutes)

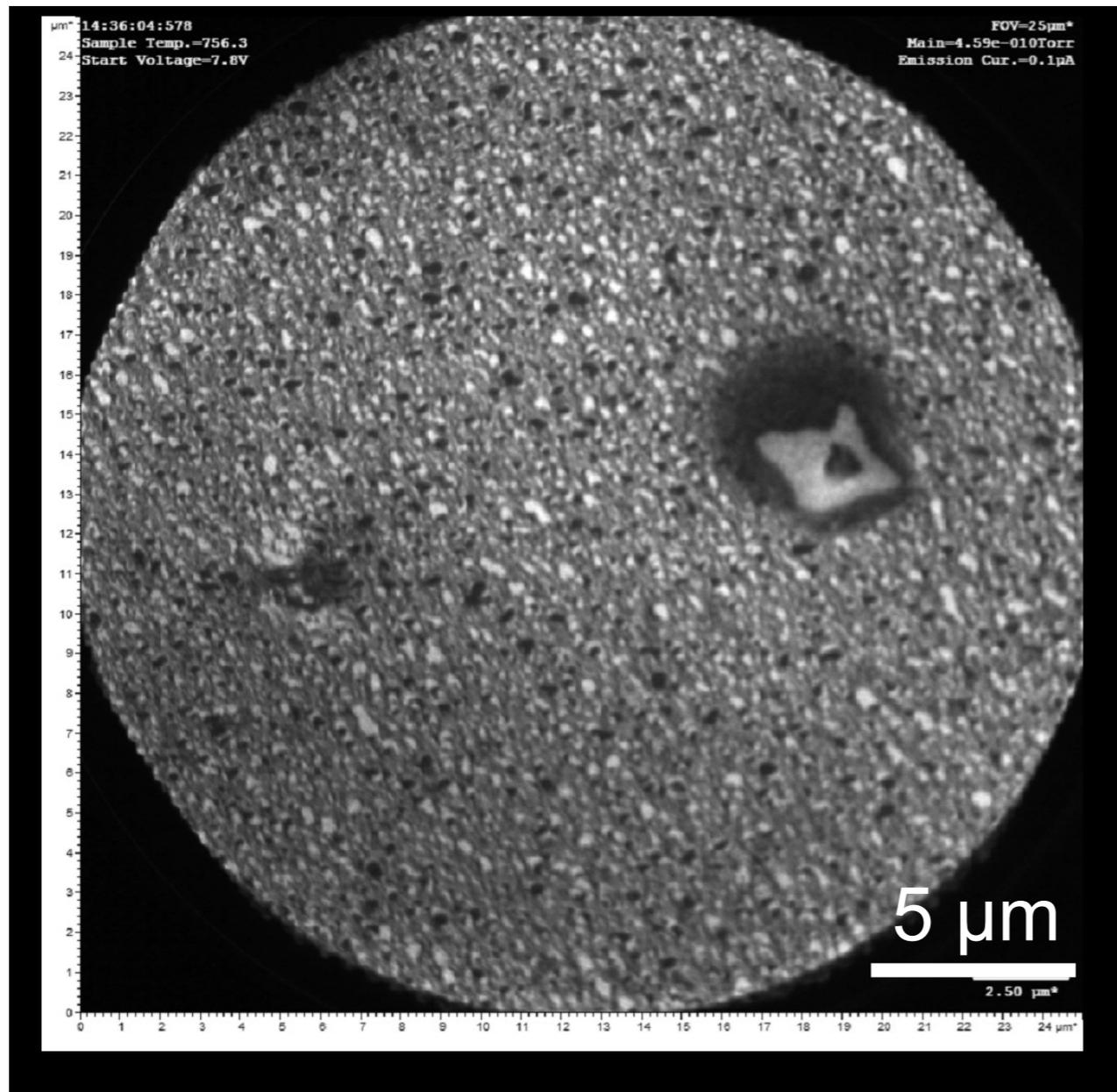
## Surface electromigration



**Biased surface diffusion under  
an applied electric field**

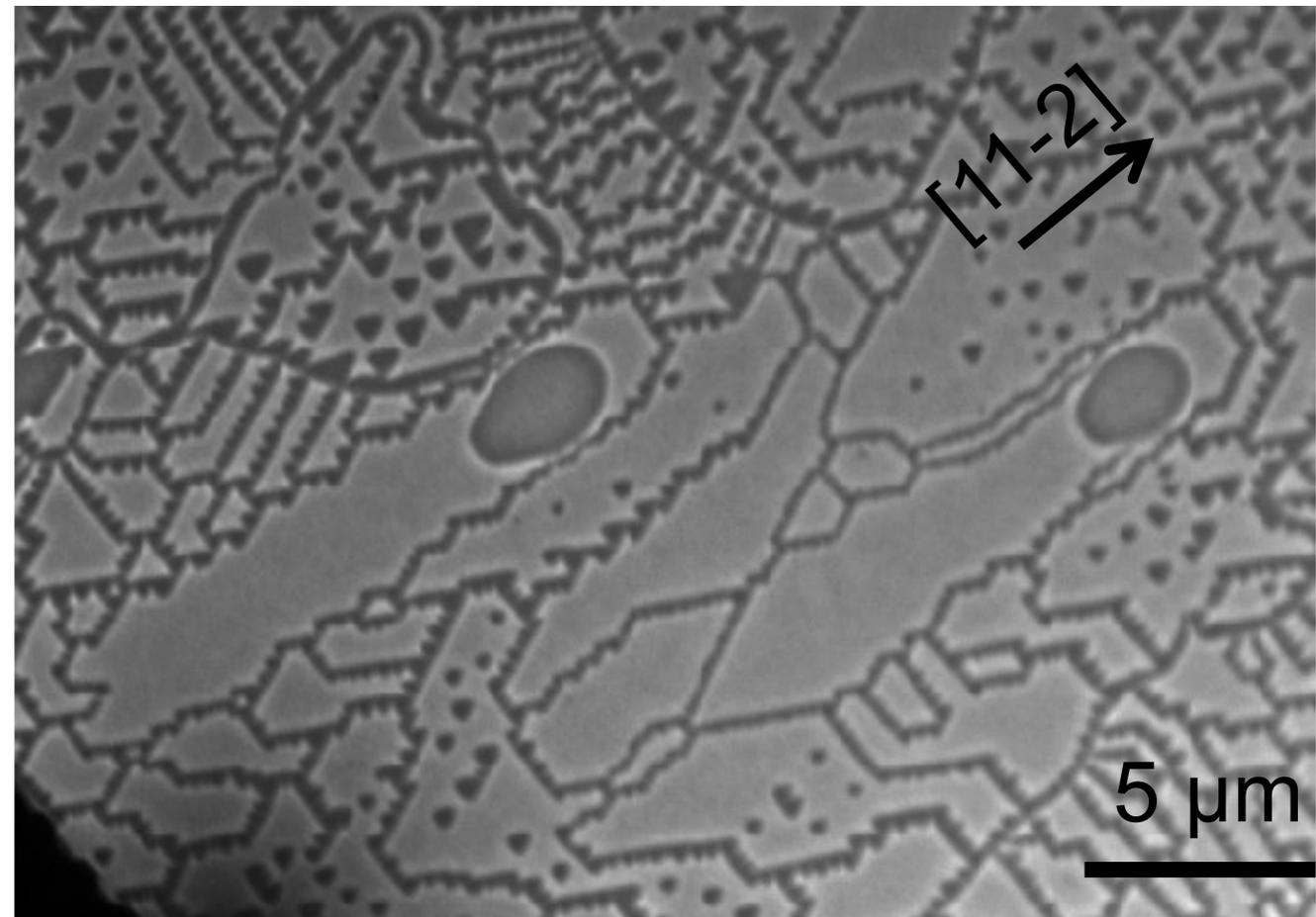
# Surface mass transport

## Solid state dewetting of thin films



22 nm Si(100) on SiO<sub>2</sub> (SOI)  
870°C;  $\Delta t = 2520$  s

## Surface electromigration



Si(111) under electric bias  
840°C;  $\Delta t = 3900$  s

# Phase transitions in ferroelectrics: GeTe thin films

Phase transition ( $T \sim 250^\circ \text{C}$ )

Diffraction X (3D)

