

# Building with DualBeam™

高海峰  
FEI 公司  
应用工程师

2017July  
中科院物理所

# Content

- **DualBeam™ 基础**
- **FIB 纳米加工应用案例/技术介绍**
- **FEI Company**

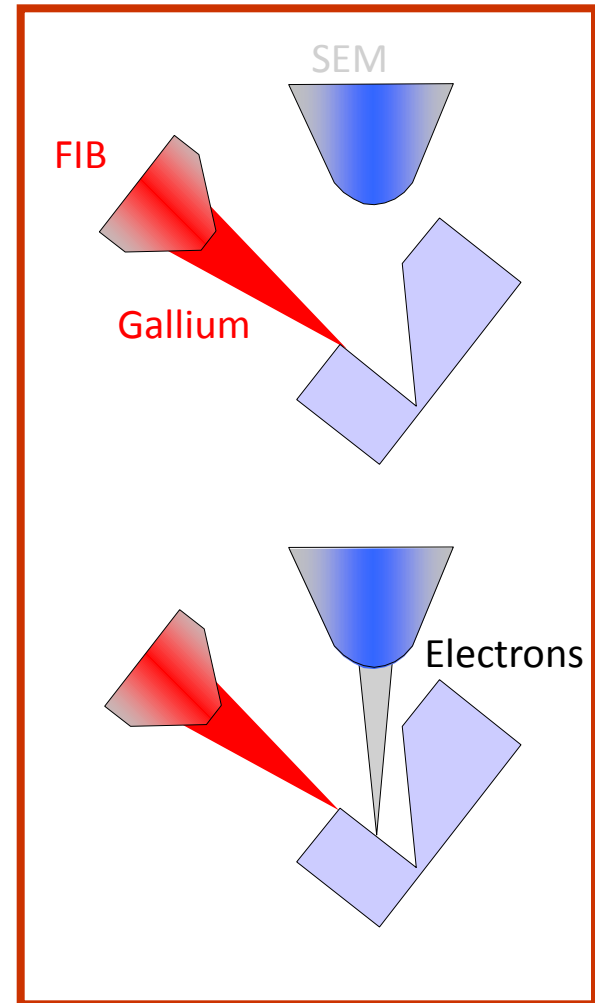
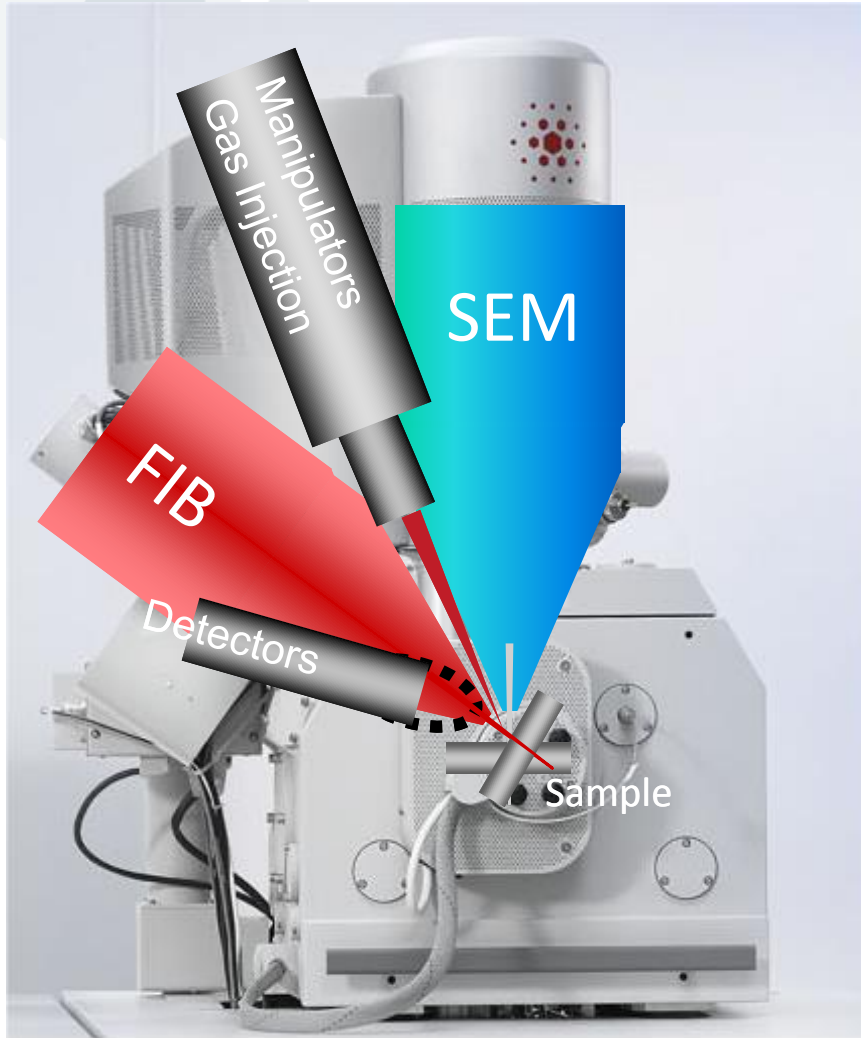
# DualBeam™ 基础

Q: What is DualBeam™

# What is a DualBeam™?

SEM: Scanning Electron Microscope

FIB: Focus Ion Beam



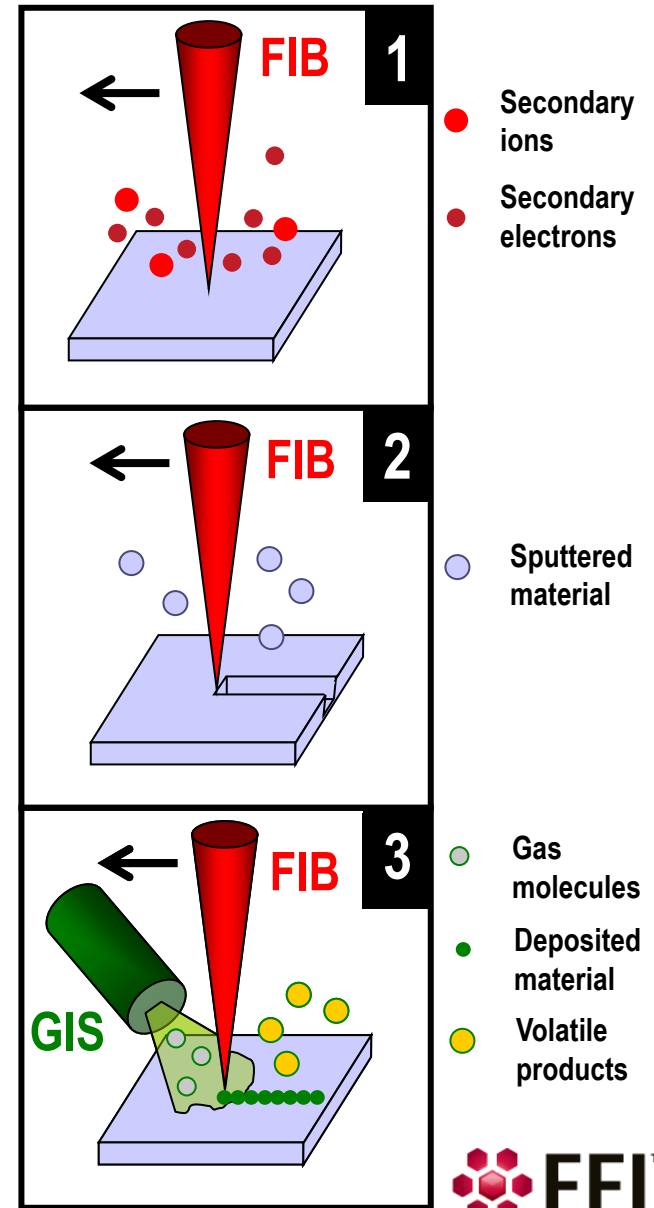
# FIB: 三个基本的工作方式

Source: 金属镓Ga

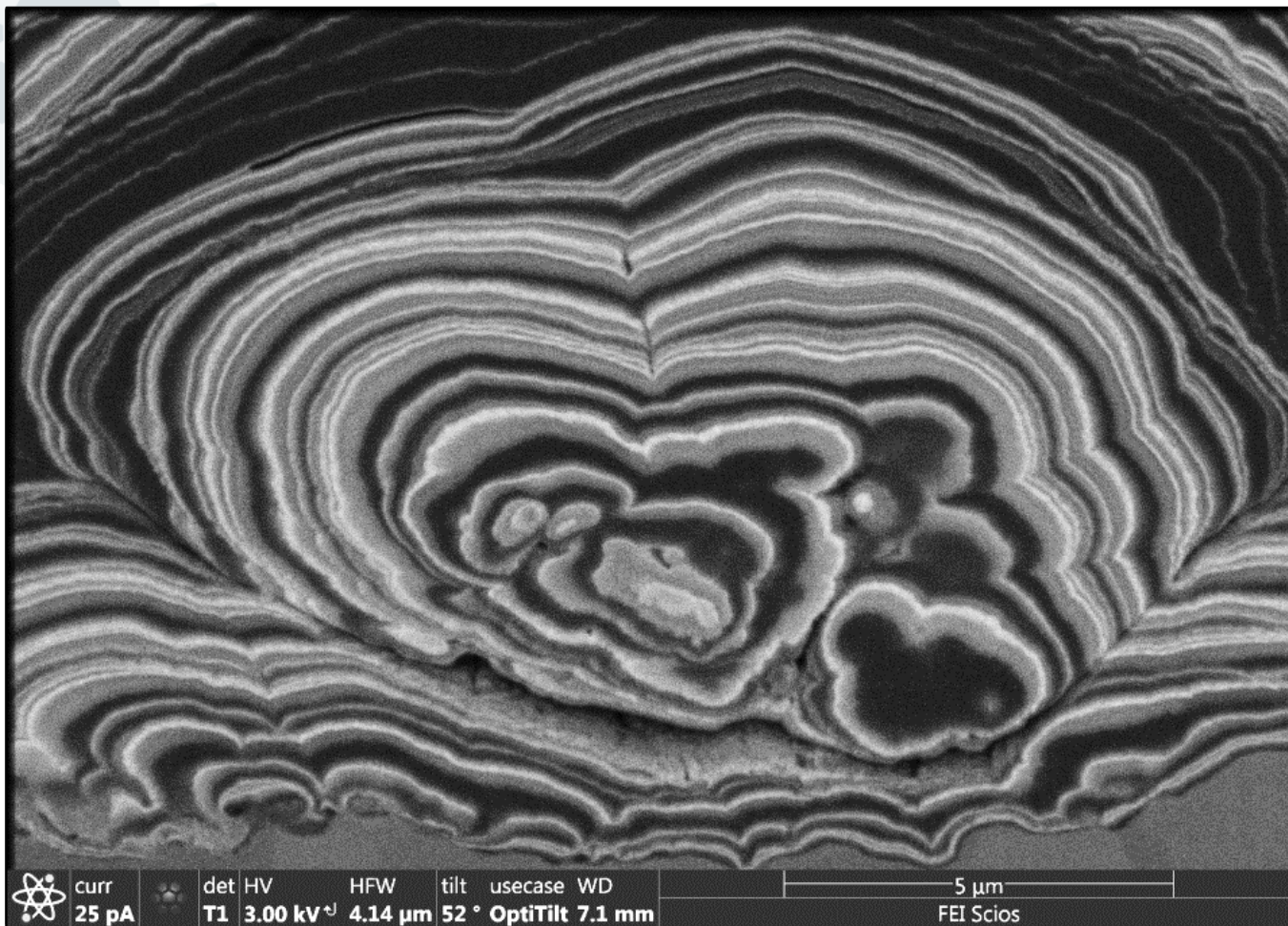
1. Emission of secondary electrons and ions
  - **FIB Imaging**
2. Sputtering of substrate atoms
  - **FIB milling**
3. Chemical interactions
  - **FIB deposition / enhanced etch**

Other effects :

- Ion implantation
- Displacements of atoms in the solid (induced damages)
- Heating

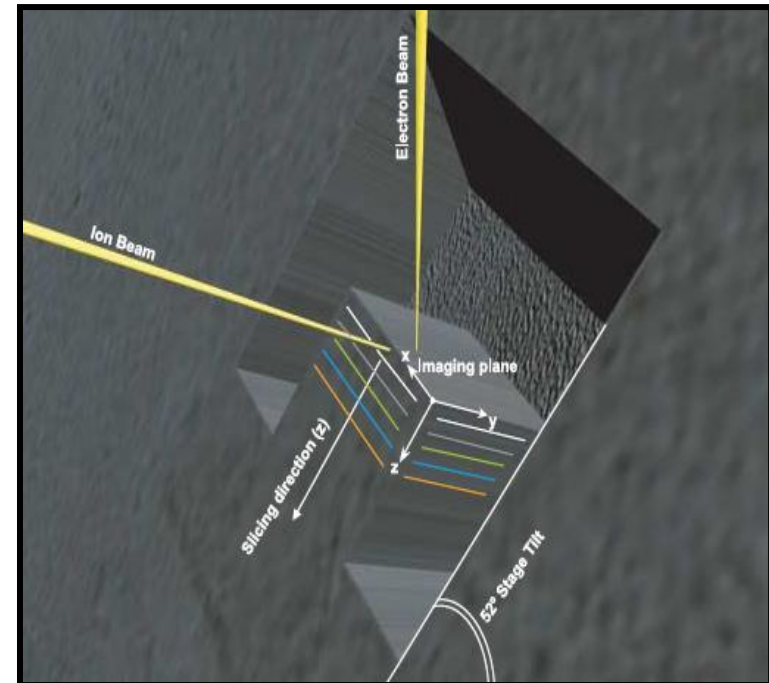
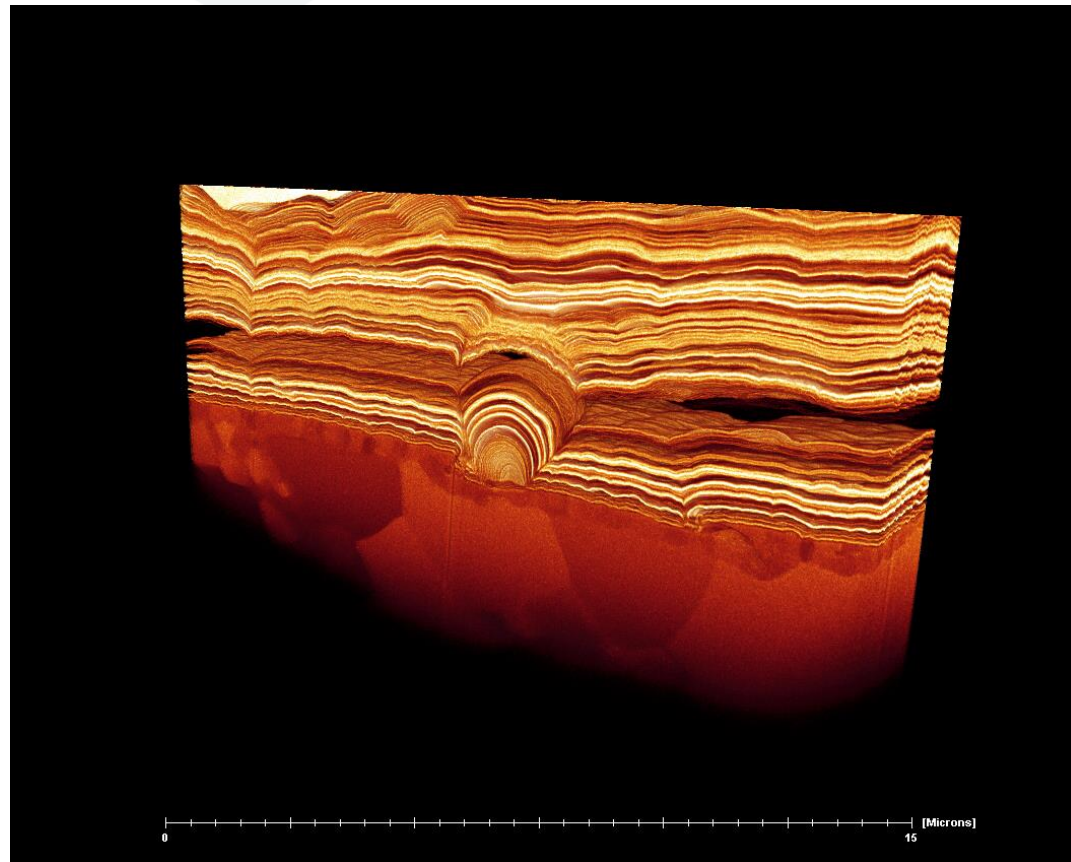


# DualBeam™应用之一：定点观测



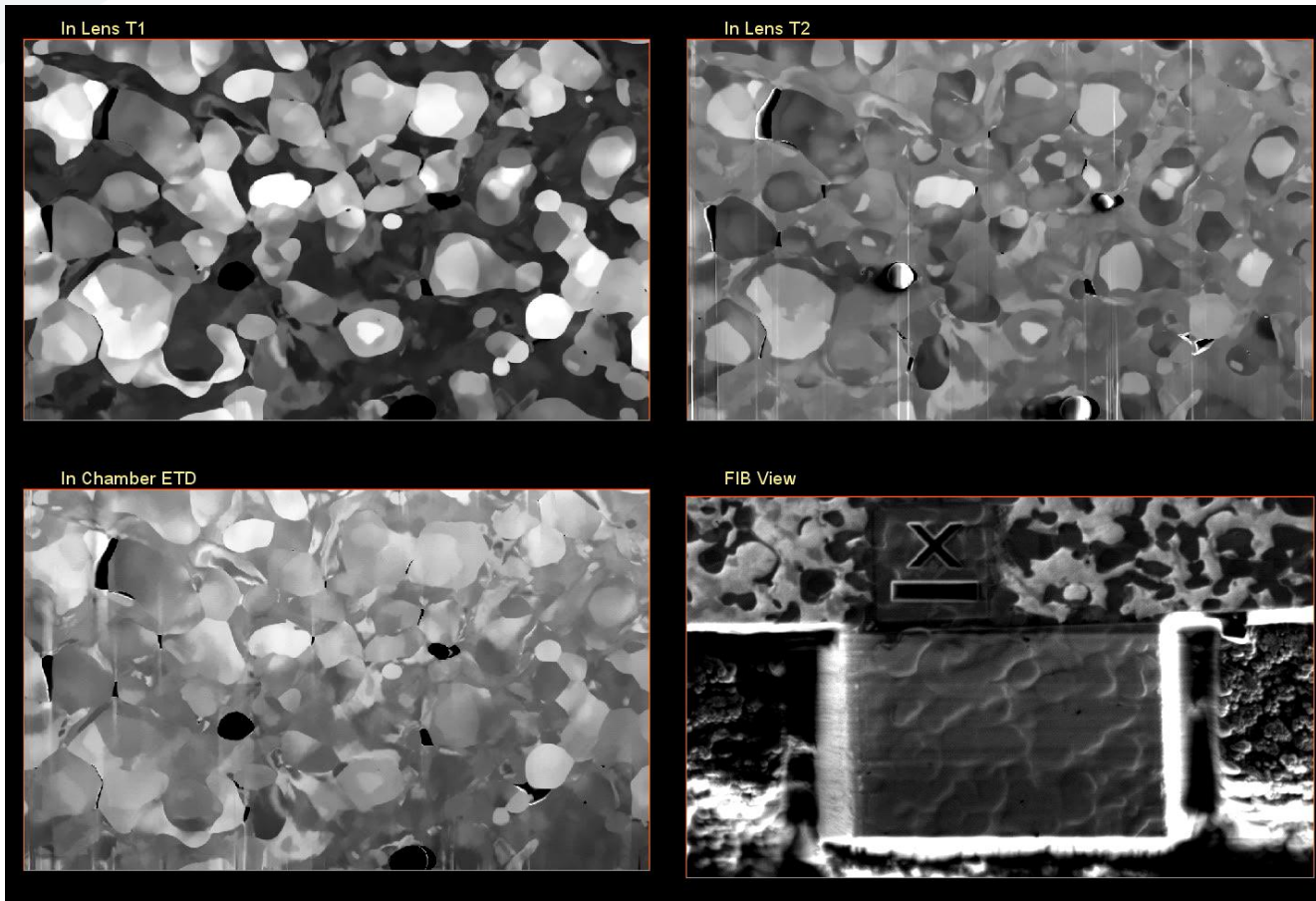
Side-by-side images significantly increase the data resolution of a coating system due to the multilayer structure of the particle

# DualBeam™应用之二：获取三维结构信息 (图形，元素，晶体取向)



# DualBeam™应用之二：获取三维结构信息

Tips: 多探头同时成像



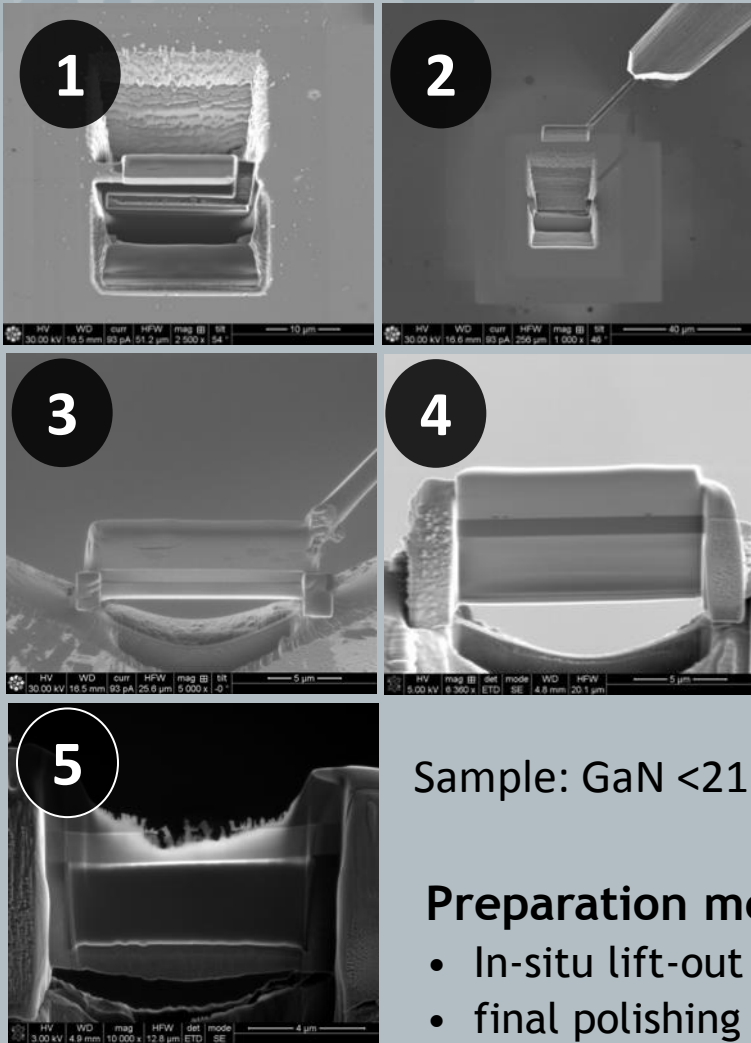
Scios  
DualBeam



er. Resolve.



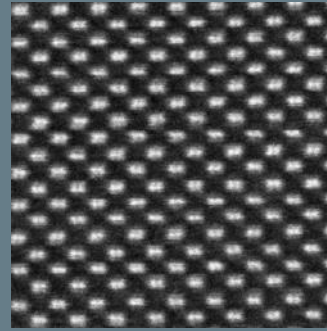
# DualBeam™应用之三： TEM 样品制备



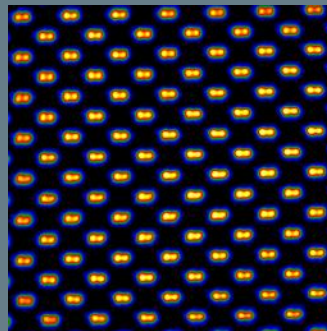
Sample: GaN <211>

## Preparation method:

- In-situ lift-out in Helios NanoLab
- final polishing performed using **1kV FIB**
- Total preparation time: **1 hour including lift out**

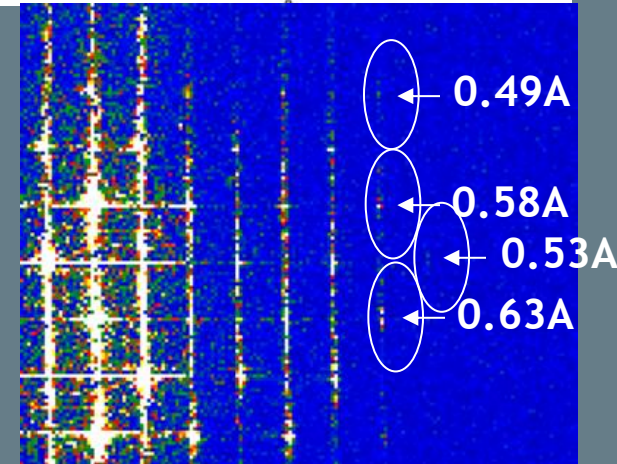
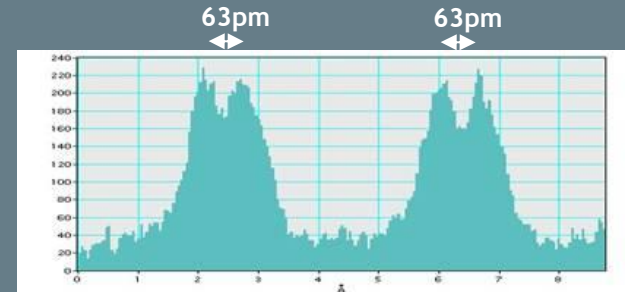


Z contrast image (raw data)



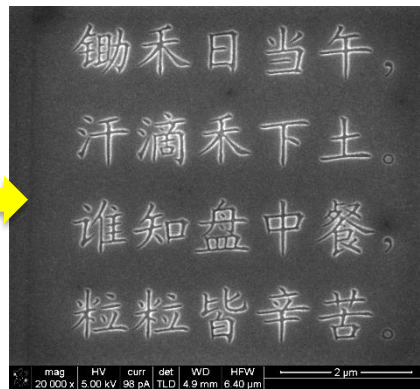
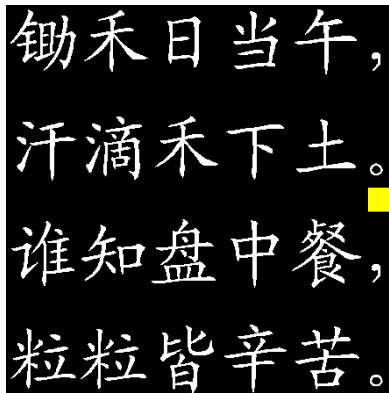
Z contrast image (filtered)

## STEM Resolution Measured with the TEAM 0.5 Column



GaN <211> power spectrum transfers till 49pm

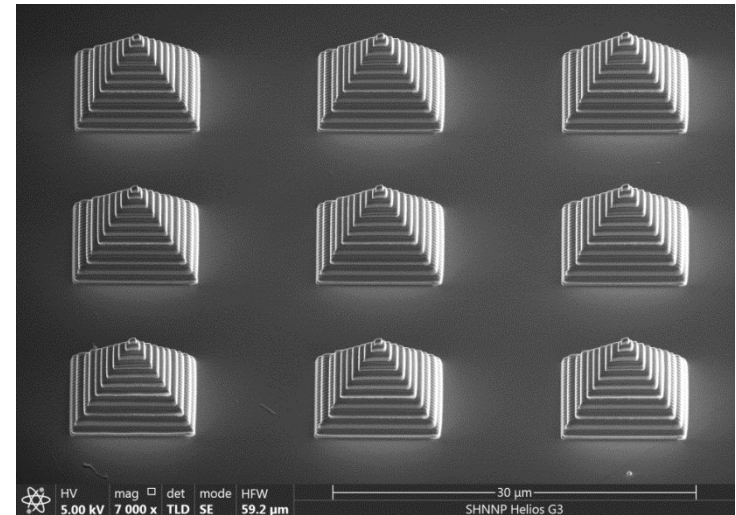
# DualBeam™应用之四：纳米原型制备



(a) Bitmap of poem (b) Poem fabricated by FIB

Nano Chinese poem fabricated by FIBM.

(F. Z. Fang et al. CIRP Annals - Manufacturing Technology 59 (2010) 543–546)

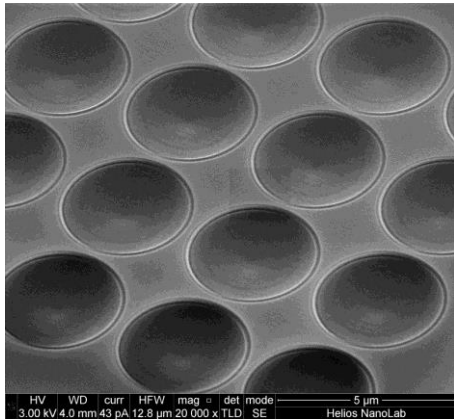


纳米金字塔

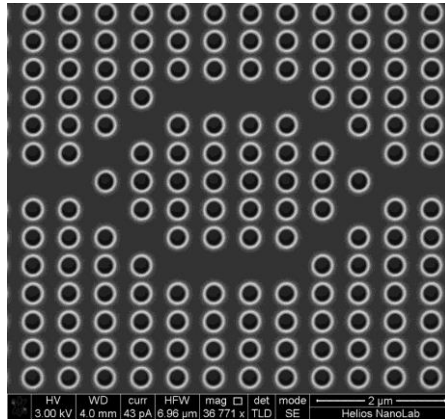
# 纳米原型制备： Prototyping with NanoBuilder™

# FIB作为微纳米加工手段的优势

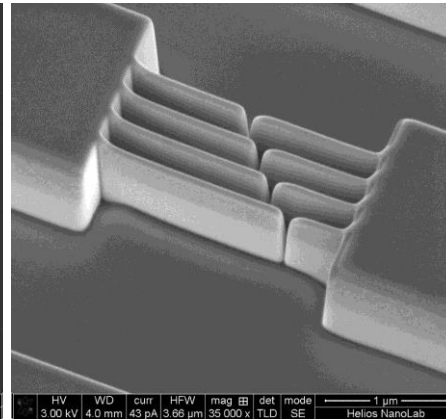
- Faster and cheaper, because only very **few steps** involved
- Flexible – **many materials** can be **milled** or **deposited** in the same tool
- Wide feature size from **mm** to a few **nm**
- Enables patterning in **3D**



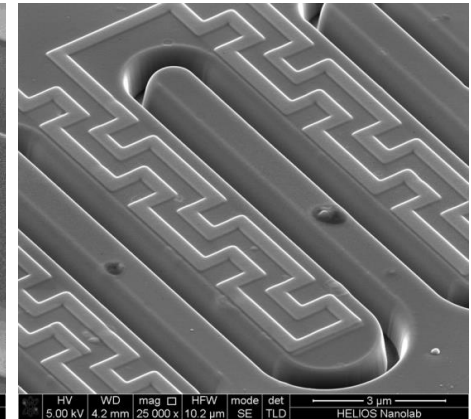
Negative microlenses



Photonic crystals



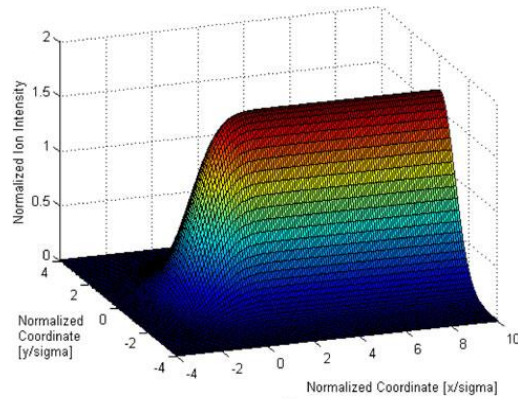
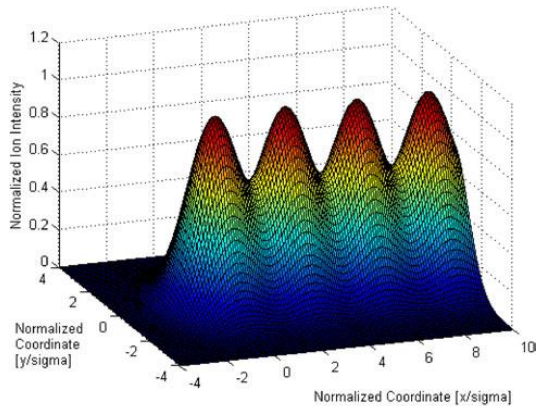
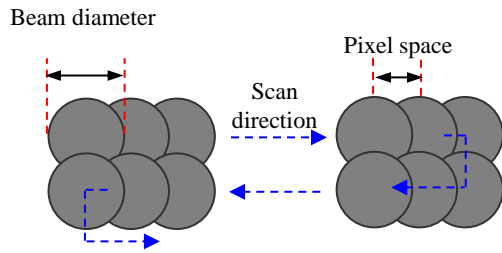
Optical nano cantilevers



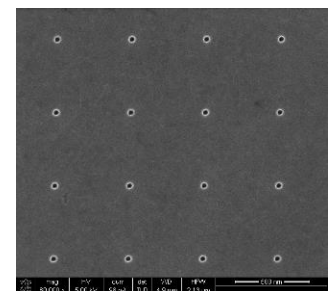
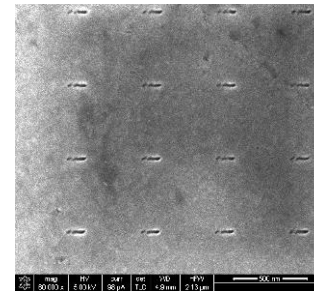
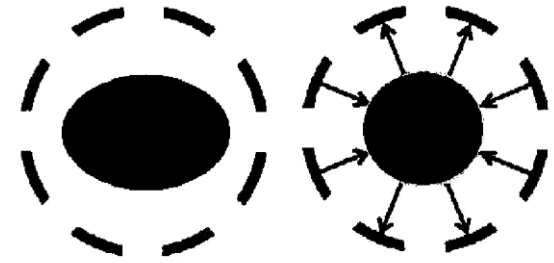
Nanofluidic device

# FIB加工的重要参数

- Beam overlap



- Beam astigmatism

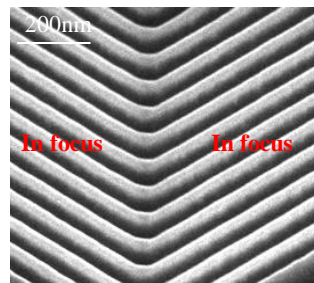
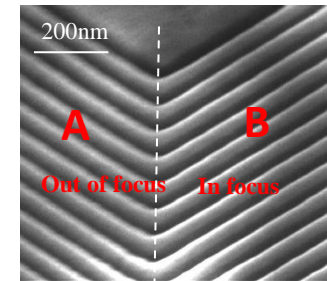
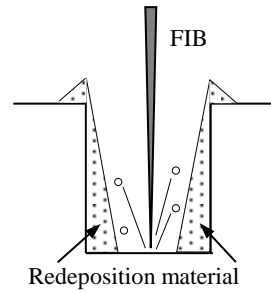


(F. Z. Fang et al. CIRP Annals - Manufacturing Technology 59 (2010) 543–546)

**Explore. Discover. Resolve.**

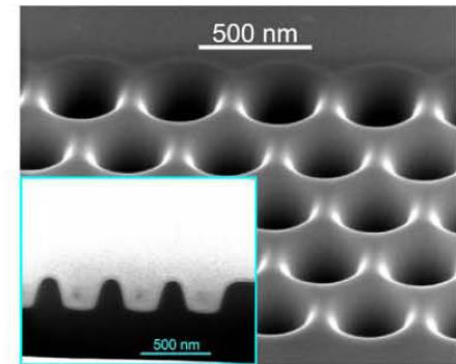
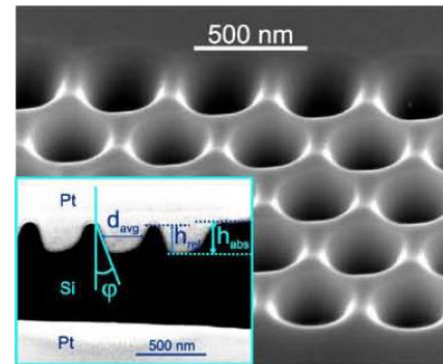
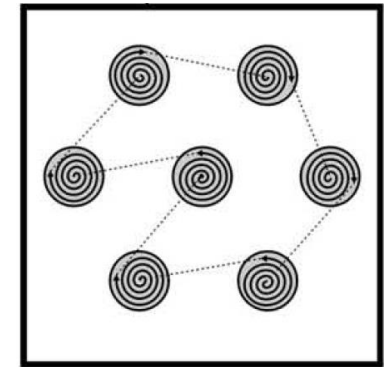
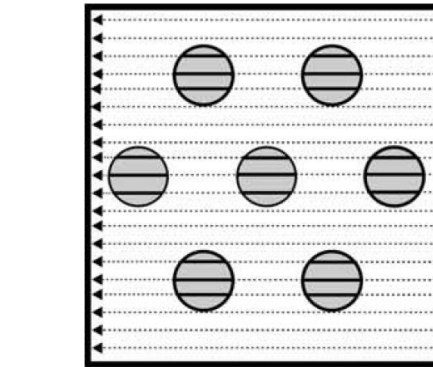
# FIB加工的重要参数

- Mill direction



(a) Bitmap of L shape mask

(b) Bitmap of V shape mask



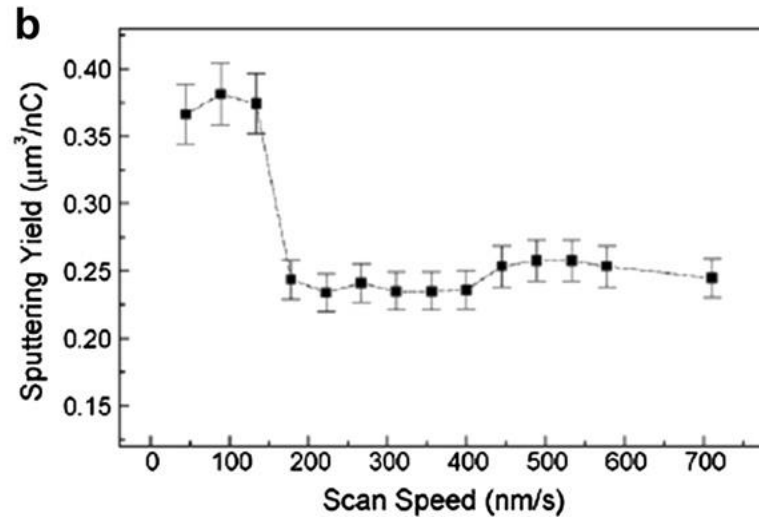
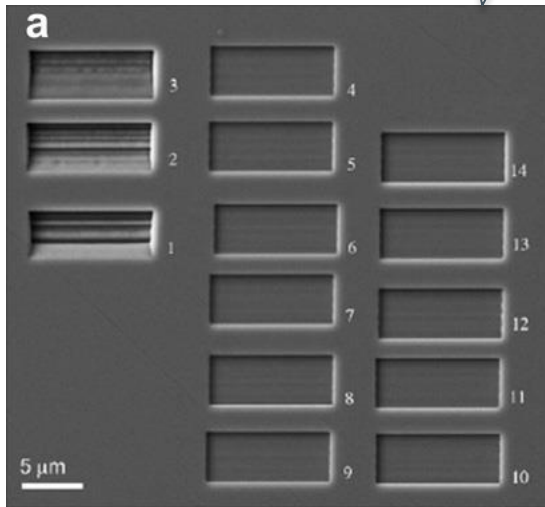
The effect of slit orientation on the FIBDW process.  
(F. Z. Fang et al. CIRP Annals - Manufacturing  
Technology 59 (2010) 543–546)

SEM images of comparing 250 nm diameter holes with 440 nm pitch  
milled into bulk silicon using different FIB scanning strategies.  
(Hopman et al. Nanotechnology 2007;18:195305.)

# FIB加工的重要参数

- Dwell time

相同剂量!

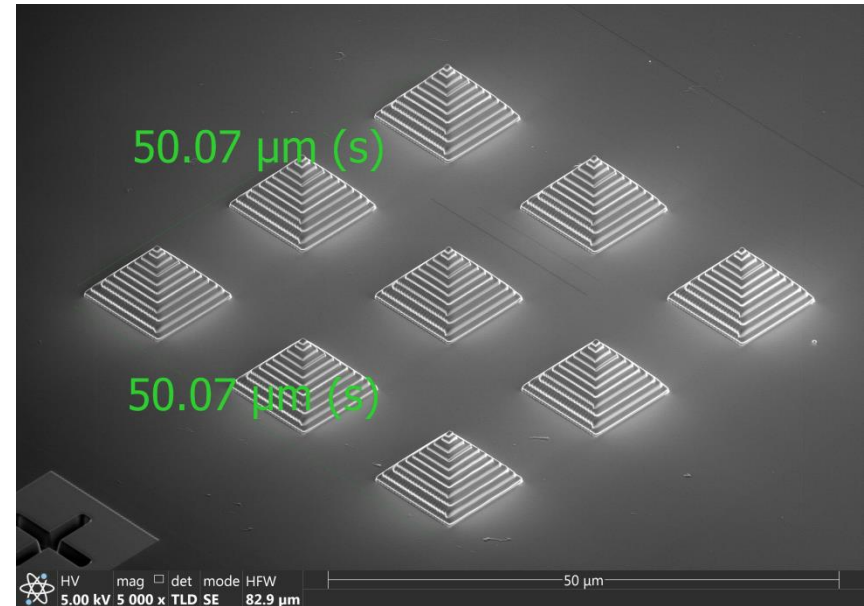
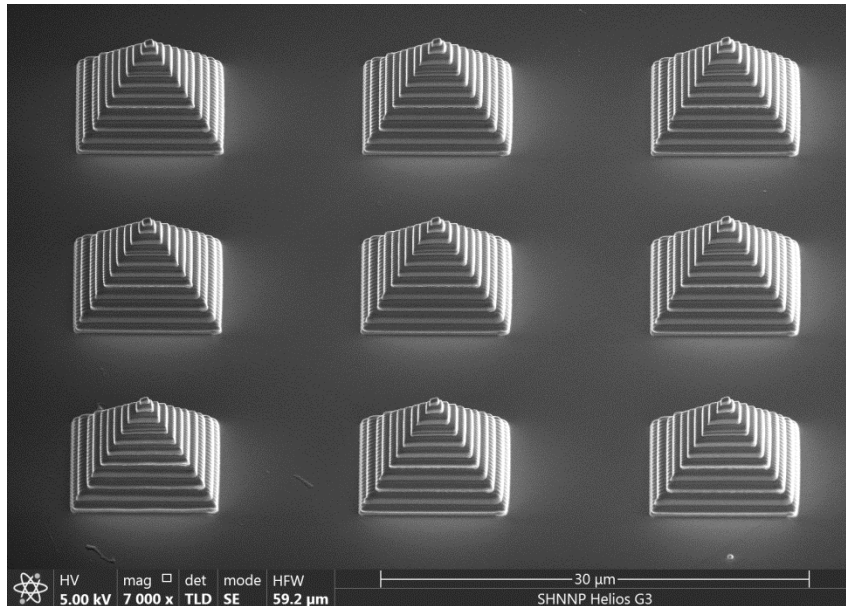
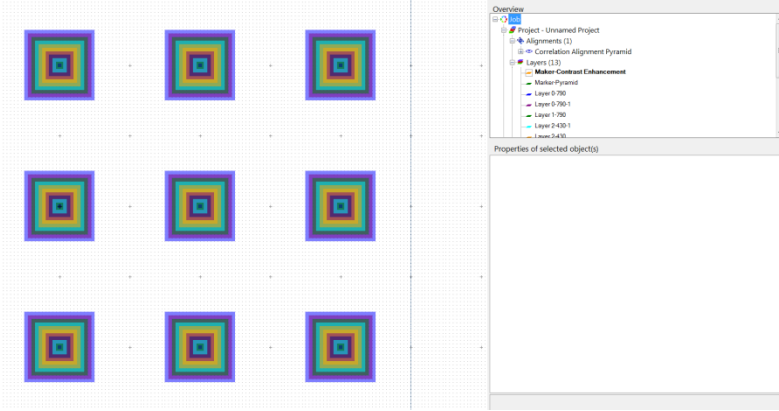


SEM image of FIB patterning as a function of dwell time on the amorphous Ni<sub>78</sub>B<sub>14</sub>Si<sub>8</sub> substrate. The scan speed was varied by varying the scan loops from 1 to 14 with constant beam exposure time of 90 s: results of (a) milled trenches and (b) Sputtering yields.

Ref: Li W etc. Appl Surf Sci 2007;253:5404

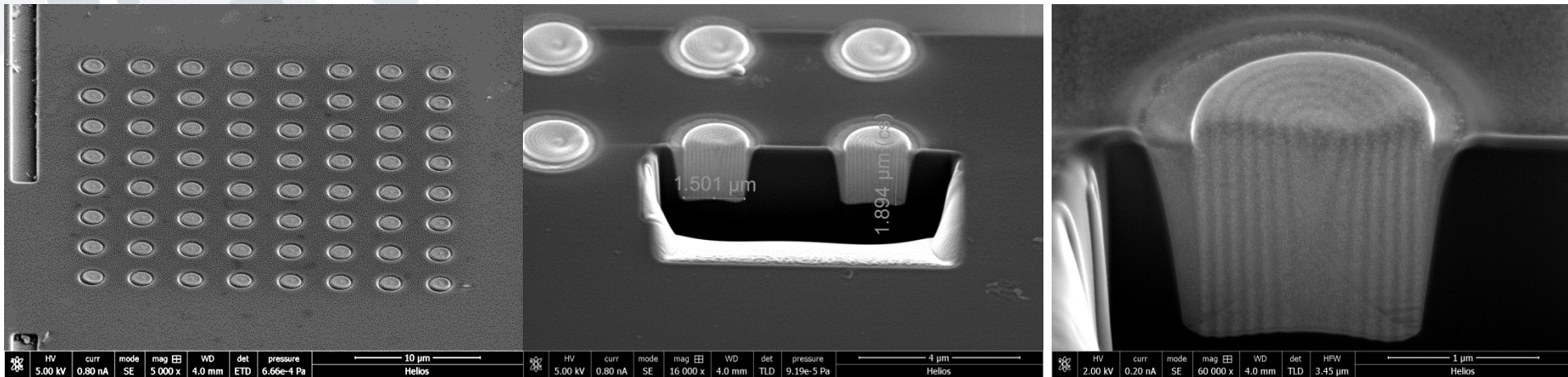
# Deposition Pyramid

Micro Pyramid Array Area: 50 $\mu$ m\*50 $\mu$ m

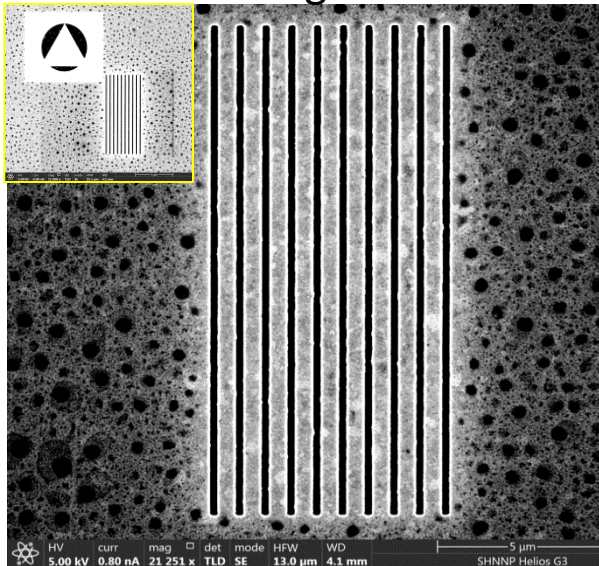




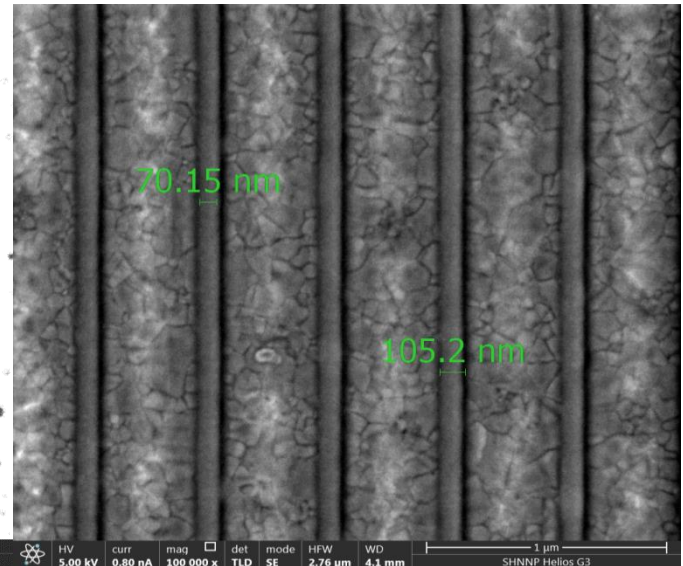
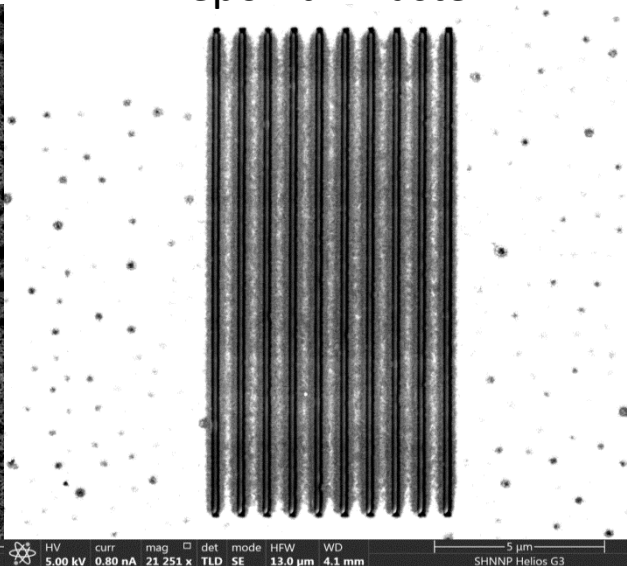
# FIB Milling + Deposition(材料置換)



Milling raster



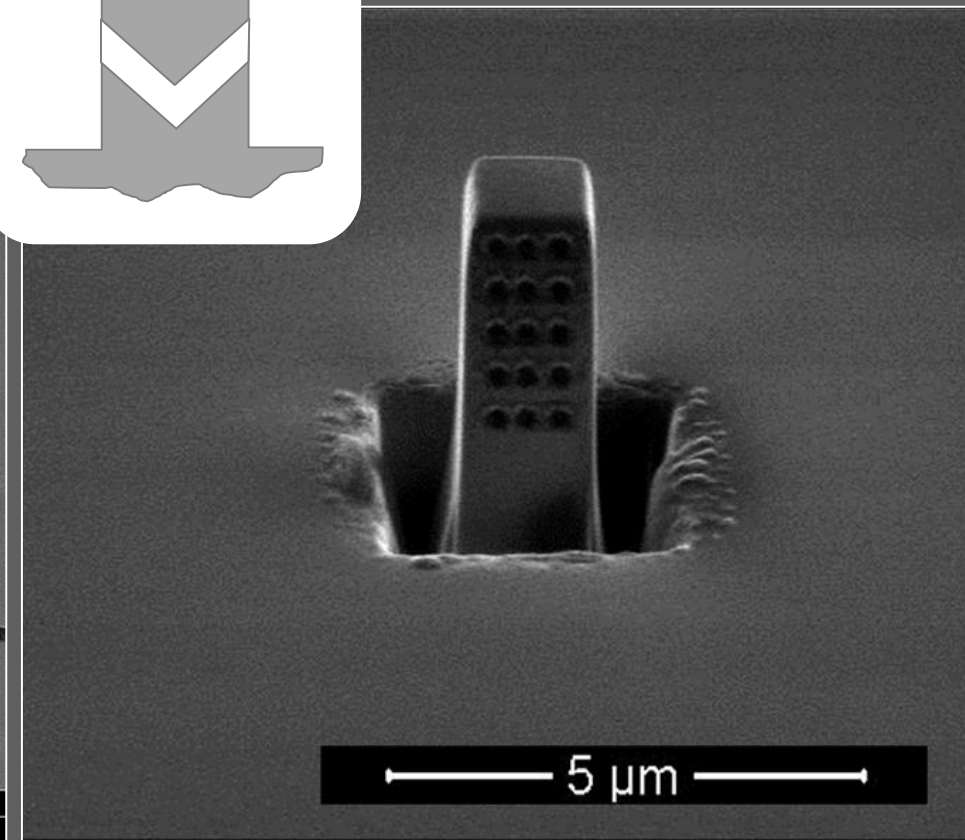
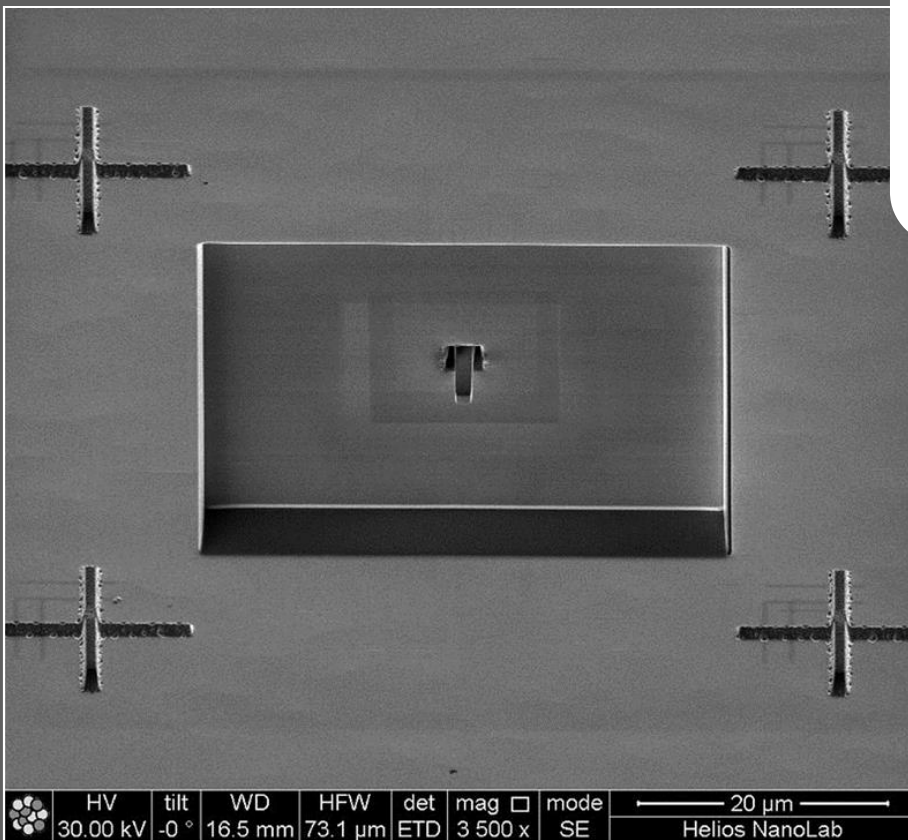
Depo Pt in raster



Explore. Discover. Resolve. Sample: 50nm Au film on SiO<sub>2</sub> substrate

# NanoBuilder 自动化加工声学器件

样品台的旋转+倾斜



# FEI公司的发展历史

**PHILIPS**

*Founded 1940s*

**fei**

*Founded 1971*

**Micrion**

*Founded 1983*

**1997/1999**



**Thank you  
Q&A**