

The valid measurement of the lattice spacing and single atomic scale step height using atomic force microscopy and transmitted electron microscopy

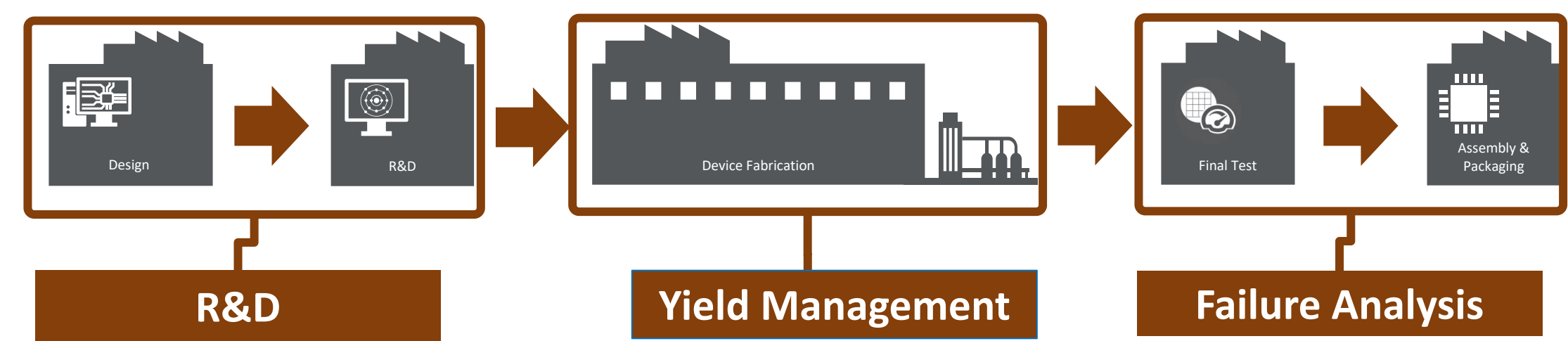
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Semiconductor manufacturing challenges



• Advanced atomic-level imaging and characterization enable high-performance materials and structural development

• Precision circuit edit enables fast-turn device prototyping and minimizes mask costs

• Reference metrology to support in-line metrology correlations

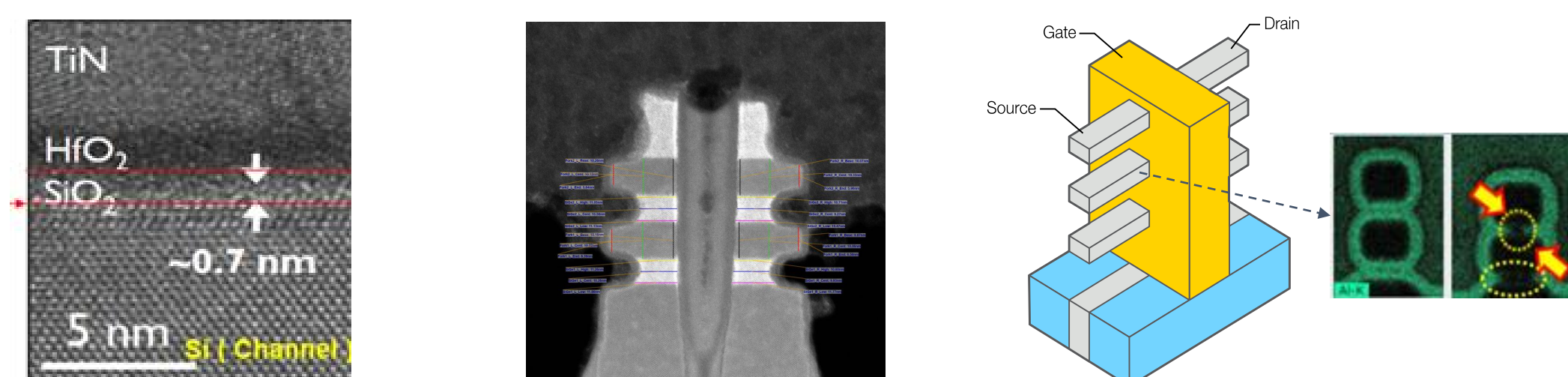
• Resolve yield excursions by providing image for root cause analysis

• Process & tool qualification by providing structural data

• Localize defect, mill through mm of material, and image with sub-nm resolution

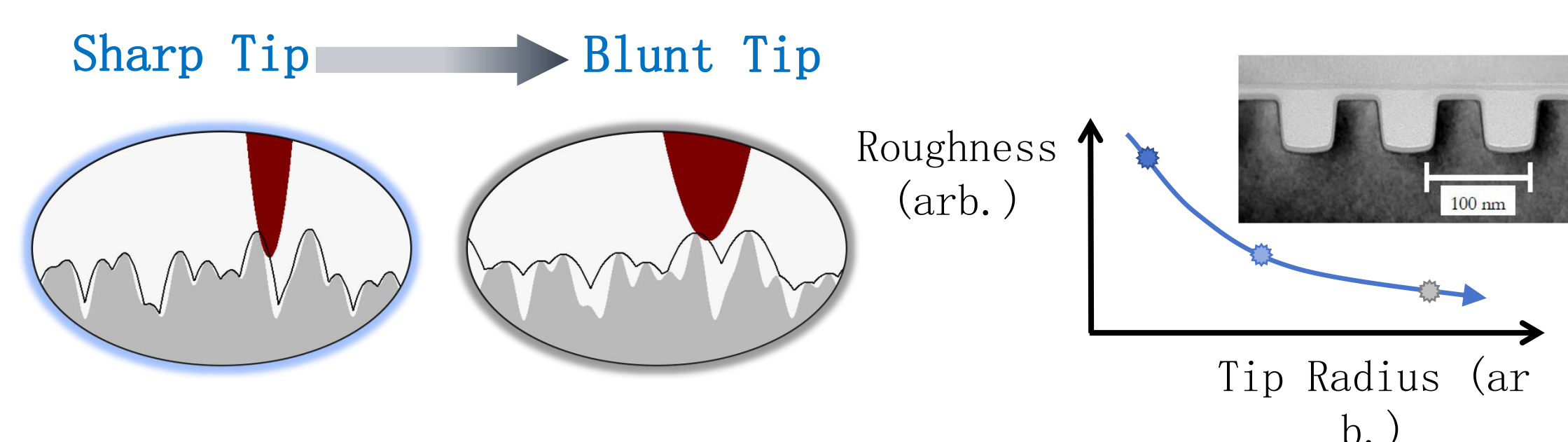
• Industry standard defect analysis workflows deliver fast root cause analysis of manufacturing samples or customer returns

TEM for semiconductor applications

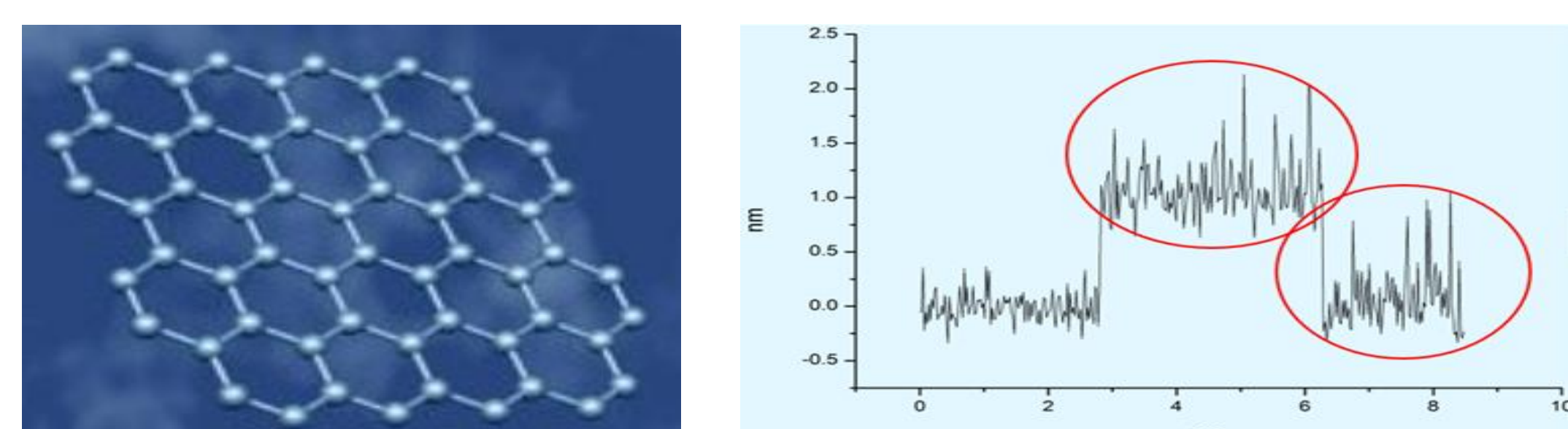


- TEM provides true, 3D metrology data to monitor and calibrate fab processes
- TEM enables root cause analysis of important “buried” defect

AFM for semiconductor and advanced material applications



Tip wearing constantly changes the tip geometry, making the measurement value non-repeatable.



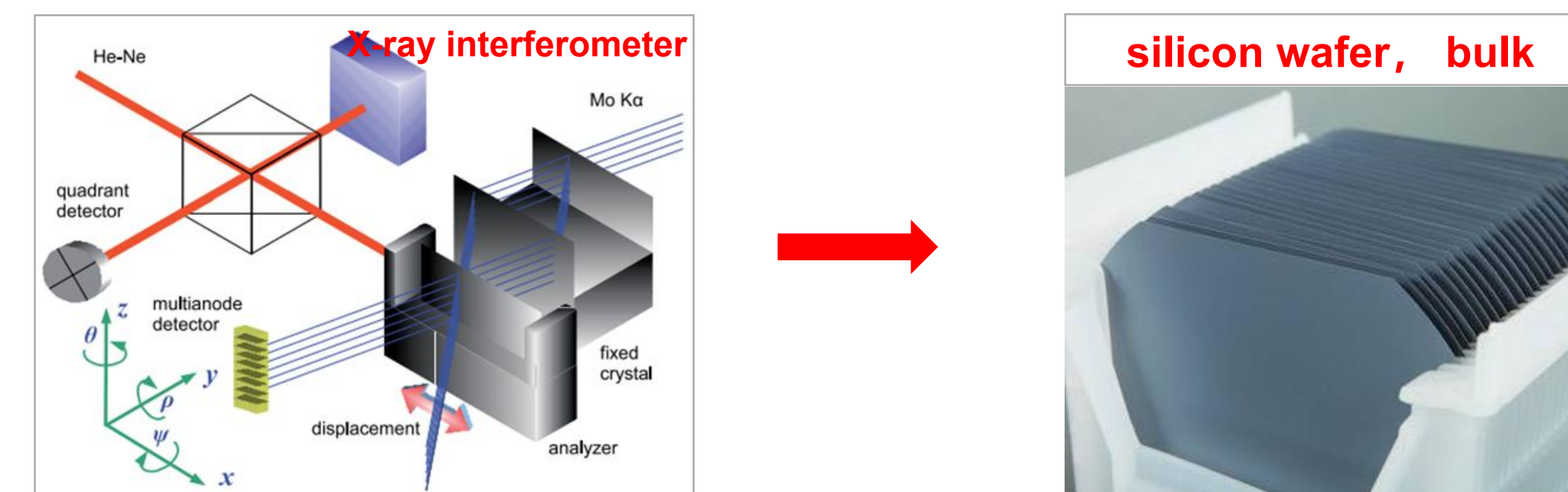
Graphene thickness is only 0.334 nm, but the measurement result using AFM is sensitive to external noise, which is larger than 0.334 nm.

TEM high magnification calibration challenges

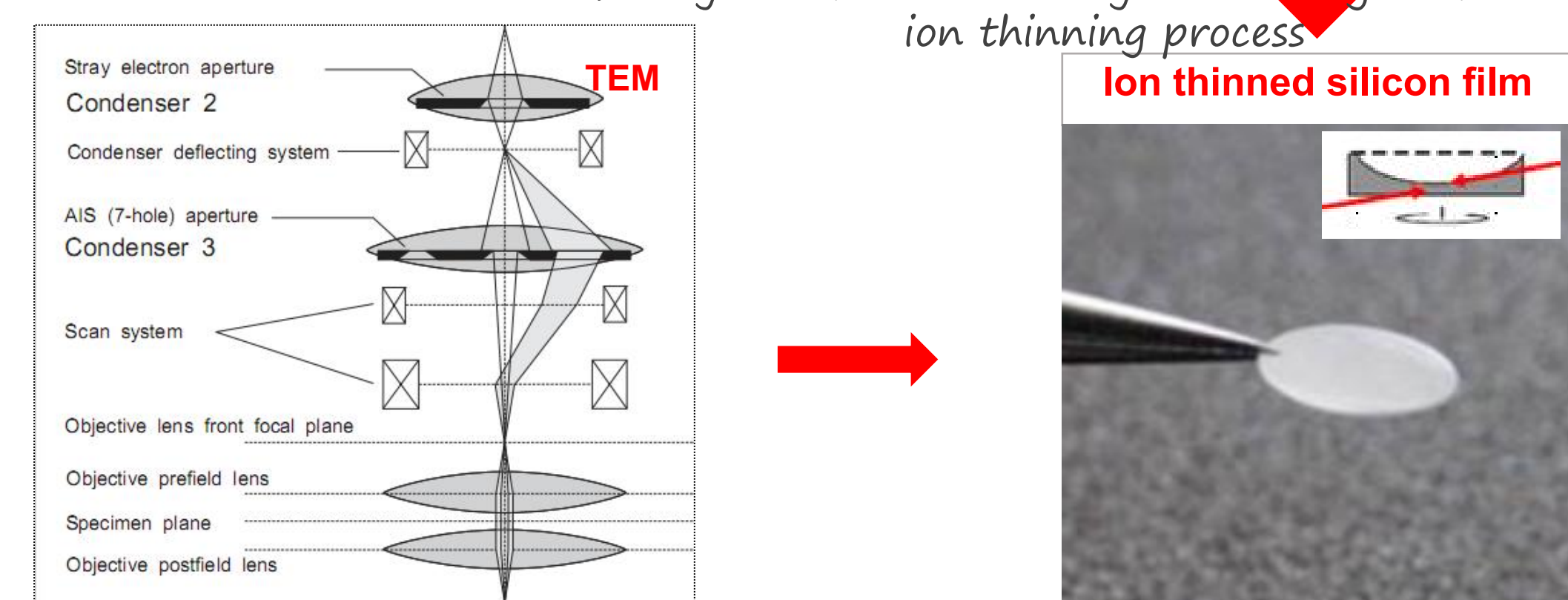
RECOMMENDATION CCL-WG-N 1 (2018)

On the entry of the Si {220} lattice parameter into the *mise en pratique*, recommends that:

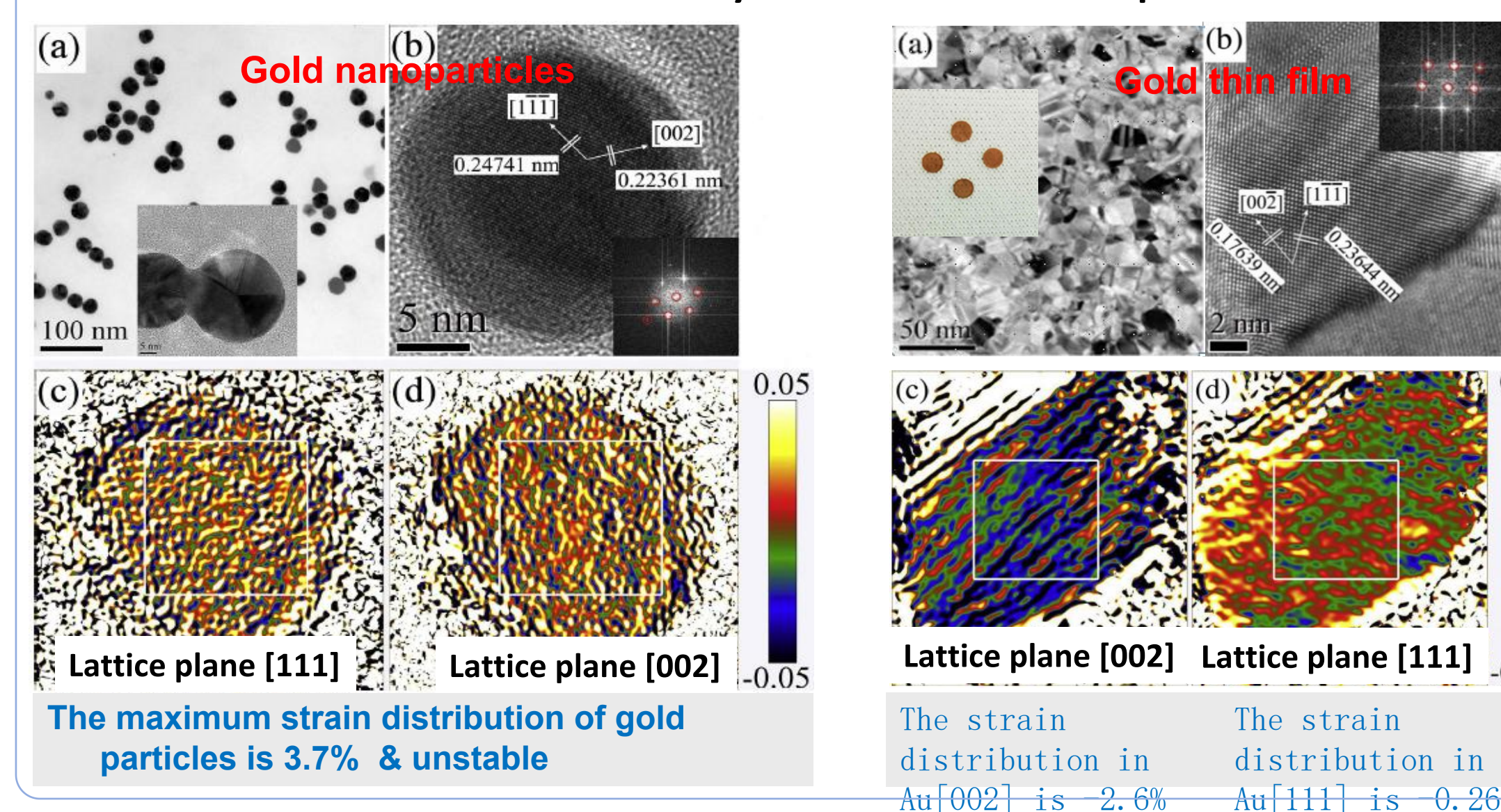
- ♦ member laboratories of the CCL increase their efforts towards making the Si {220} lattice spacing an available standard for use in providing traceability to the SI metre for dimensional nanometrology applications in the broader sense;



The value of the silicon wafer determined by the X-ray interferometer may have changed after the ion thinning process

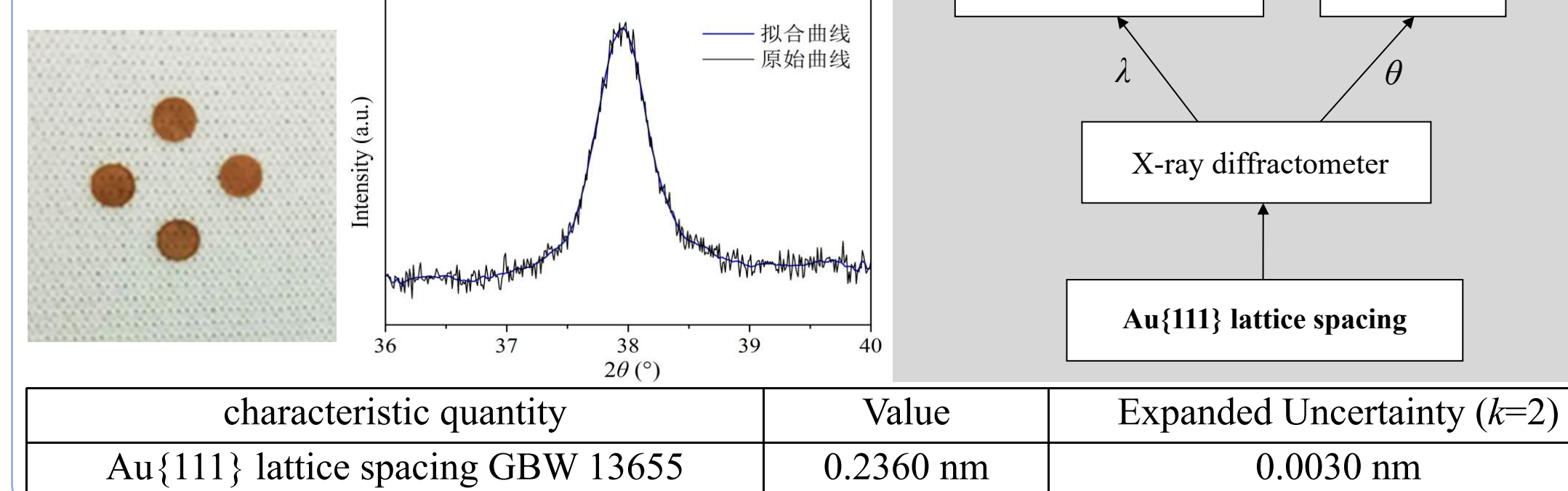


Strain induced by manufacture process



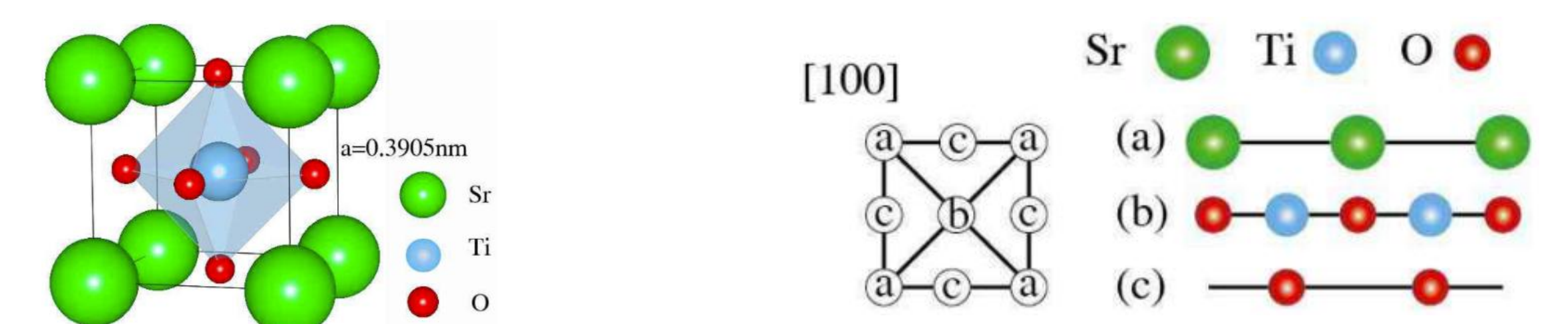
Au[111] lattice spacing CRM for TEM high magnification calibration

- **stable under high energy electron beam**
- **large scale with low defect**
- **with low stress and strain**
- **easy to produce**
- **Be directly used to calibrate TEM without additional processing after its standard value was defined**



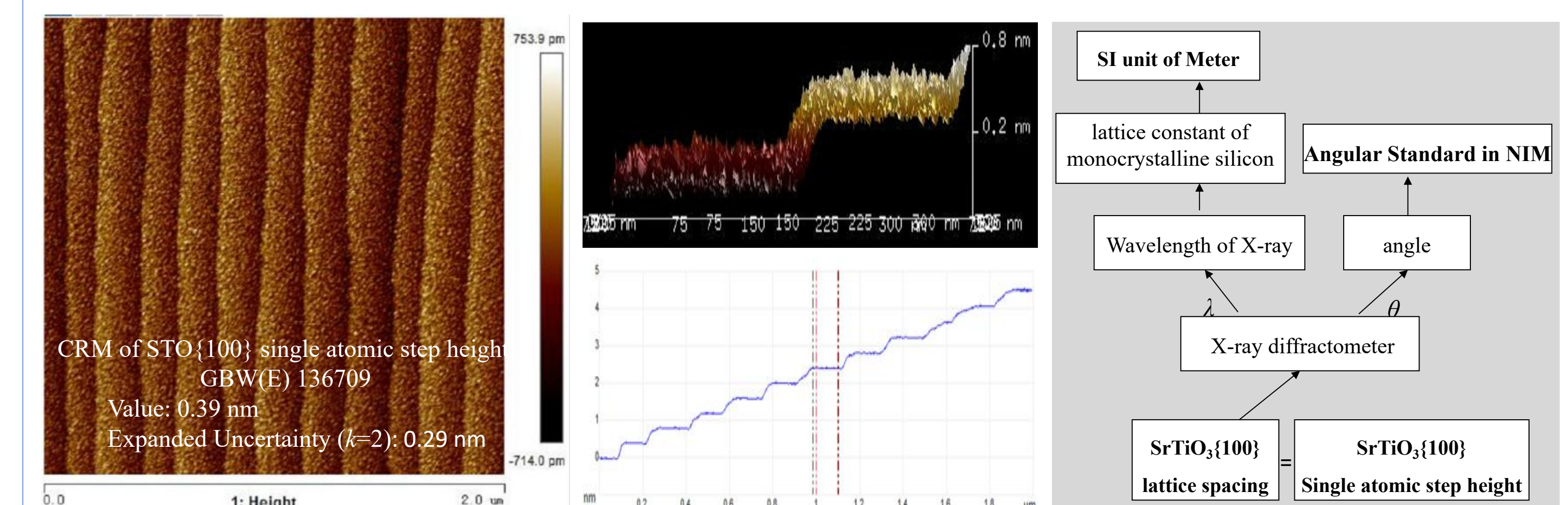
CRM development of single atomic step height for AFM calibration

Structural Characteristics of strontium titanate and its applications



- [100] Crystal Plane Structural Characteristics of strontium titanate (SrTiO₃, STO): The atomic arrangement is the most compact, with the lowest surface energy and high stability.
- **Applications:** It is commonly used for thin film growth and heterojunction preparation, making it an ideal choice for studying interfacial physical and chemical properties.

CRM development of STO{100} single atomic step height



Measurement of graphene oxide thickness using AFM by STO{100} CRM calibration

