Building College-University Partnerships for Nanotechnology Workforce Development

X-ray Diffraction (XRD)

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PennState

Welcome

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Nano-Educators Topical Seminar Series

- 09-17 Optical Lithography
- 09-24 **Wave-Based Characterization**
- 10-01 Plasma Technology
- 10-08 MEMS
- 10-15 FIB, SEM and E-beam Lithography
- 10-29 TEM
- 11-05 Microfluidics
- 11-12 Nano-medicine

Review of Fabrication and Characterization

Fabrication and Characterization

- Fabrication
  - “Making Something”
  - Adding material
  - Removing material
  - Shaping material
  - Modifying a material
- Fabrication Examples:
  - Lithography
  - Etching
  - Deposition
- Characterization
  - “Looking at something”
  - Analyze shape
  - Analyze structure
  - Analyze composition
  - Analyze properties
- Characterization Examples:
  - Microscopy
  - Spectroscopy

Characterization

JamBoard: What characterization techniques have you used?

Wave-Based Characterization Techniques

Wave type

- Electromagnetic waves
- Sound waves
- Particle Waves

Wave coverage

- Ensemble
- Scanning
- Pulse

Today, we'll discuss

- XRD
- XPS
- UV-Vis
- FTIR

X-Ray Diffraction (XRD)

X-Ray Diffraction or XRD

- Instrument: X-Ray Diffractometer
- Usually crystalline samples
- Composition and structural analysis
- “Non-destructive” and relatively fast

Image: Florida St. University

Image: NASA

X-Ray Diffractometer

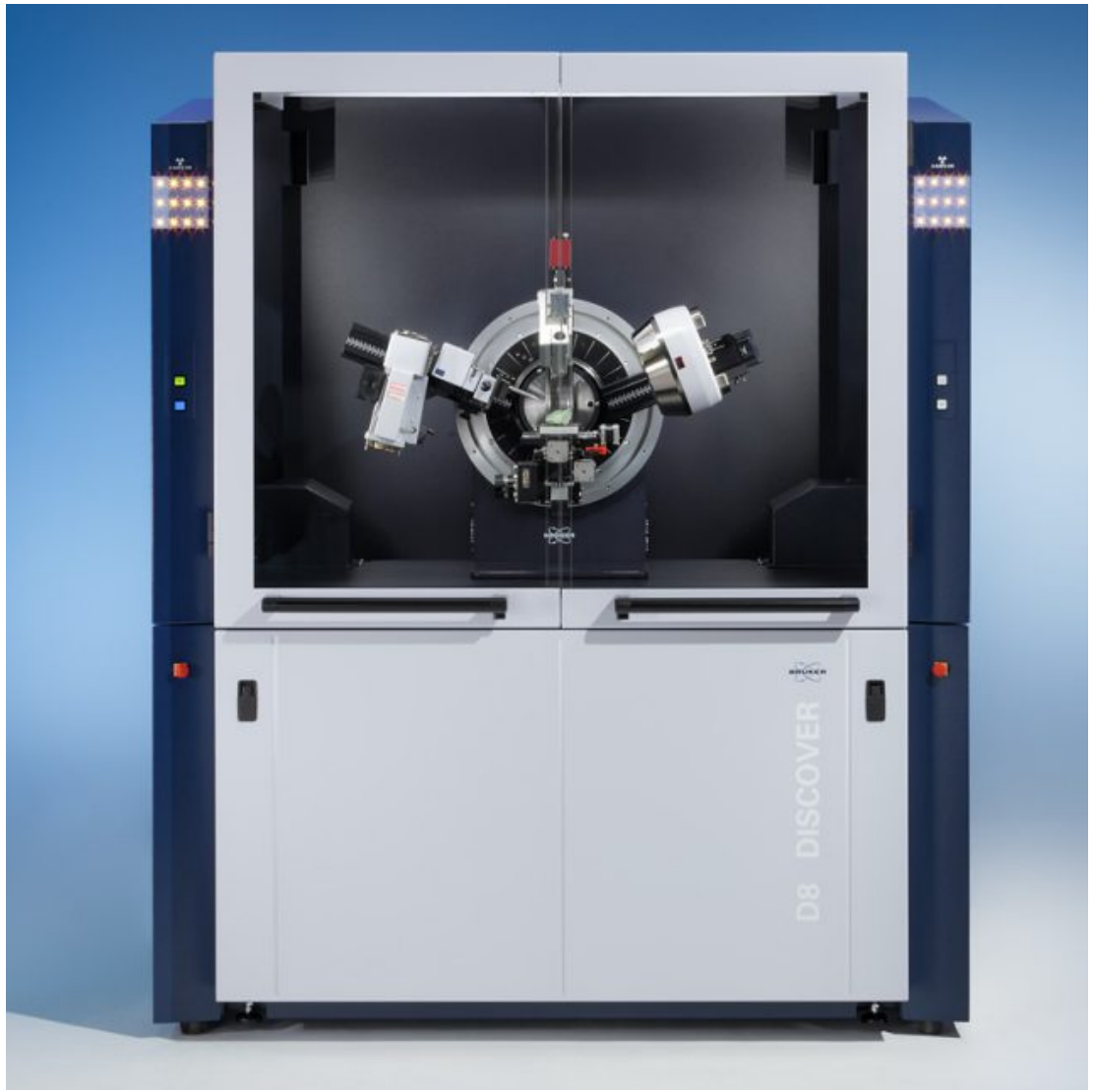

Image: Bruker

- X-rays generated from a source
- X-ray beam interacts with sample
- Diffracted x-rays collected by a detector

X-Rays

- Electromagnetic Radiation
- Wavelength:
  ~ 0.1 Å to ~ 100 Å
- X-ray wavelength is around the same size scale as atomic arrangements

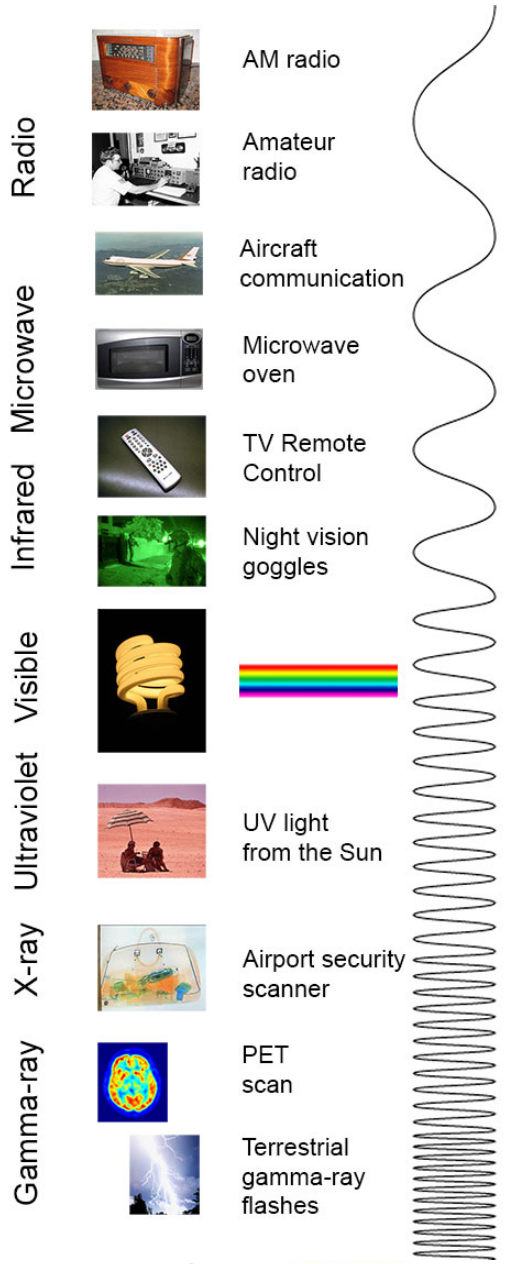

Image: NASA

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Parts of an X-Ray Diffractometer

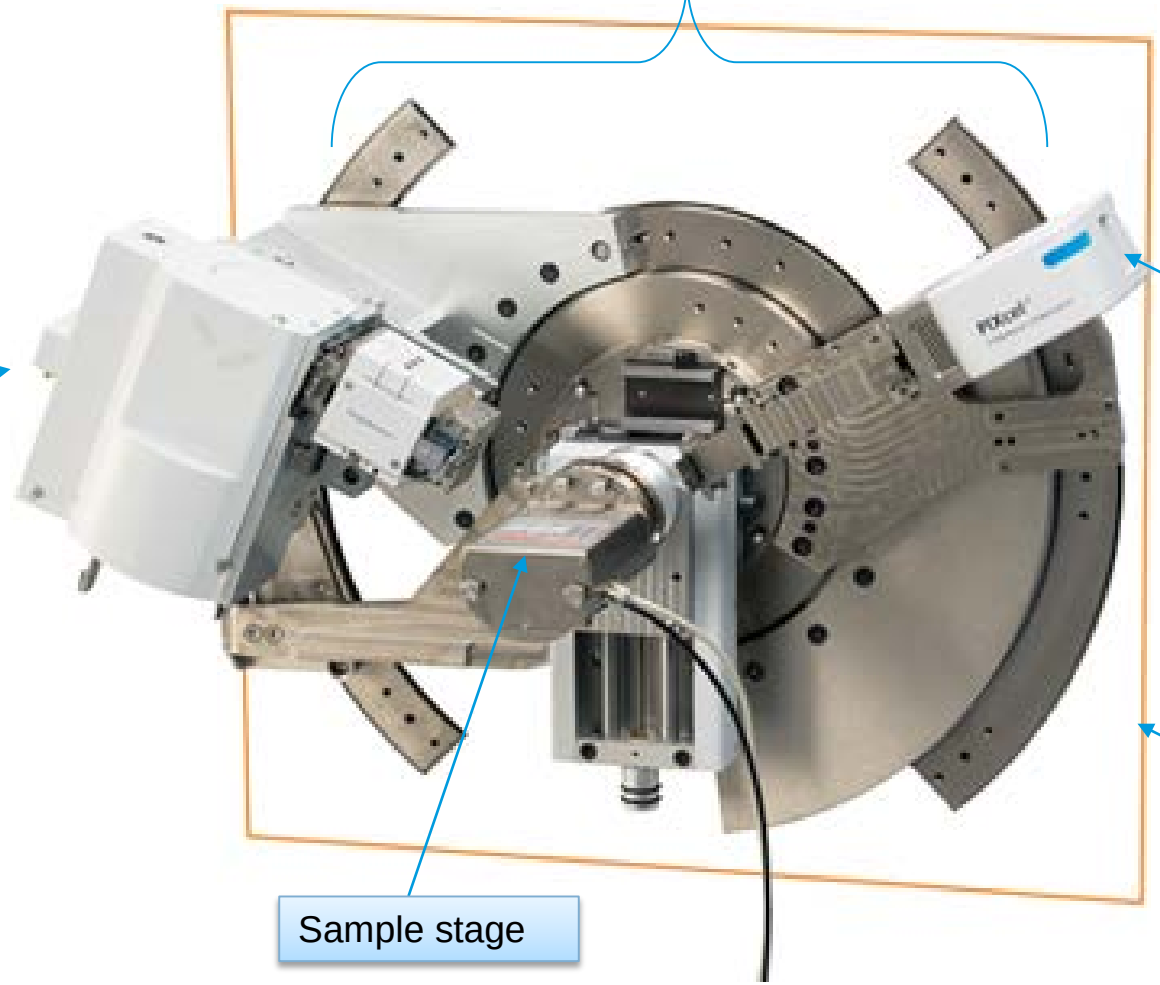


Image: Malvern

X-ray Sources

- Hot filament generates electrons
- High energy electrons strike metal anode
- X-rays emitted from Anode
- Anode materials: Cu, Cr, Mo, Co, Fe, Mn
- Slits and windows used to control x-ray beam

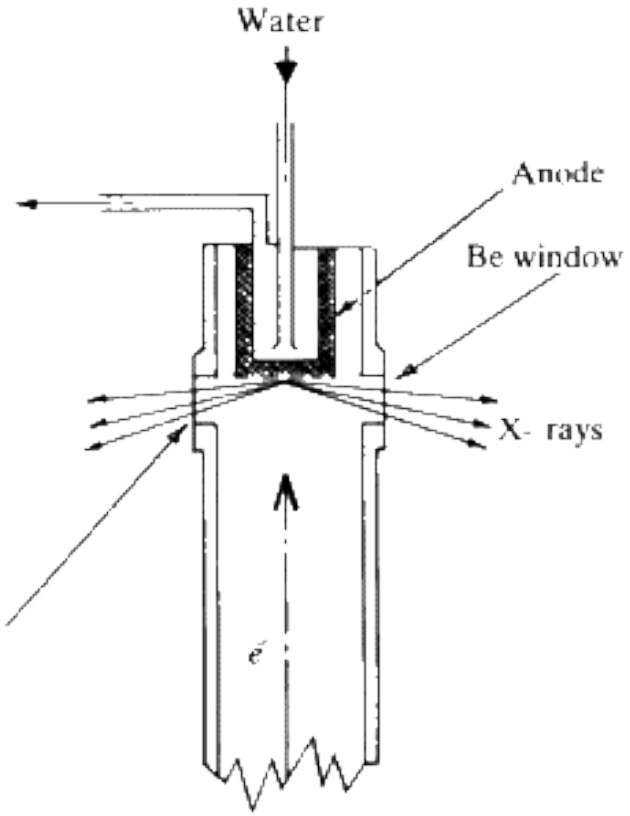


Image: UofO Chemistry

Image: Malvern

Goniometer

- A *goniometer* measures angles
- In XRD, angle of x-ray source and detector relative to the sample is changed
- As the goniometer rotates through angles, the detector records diffracted x-rays

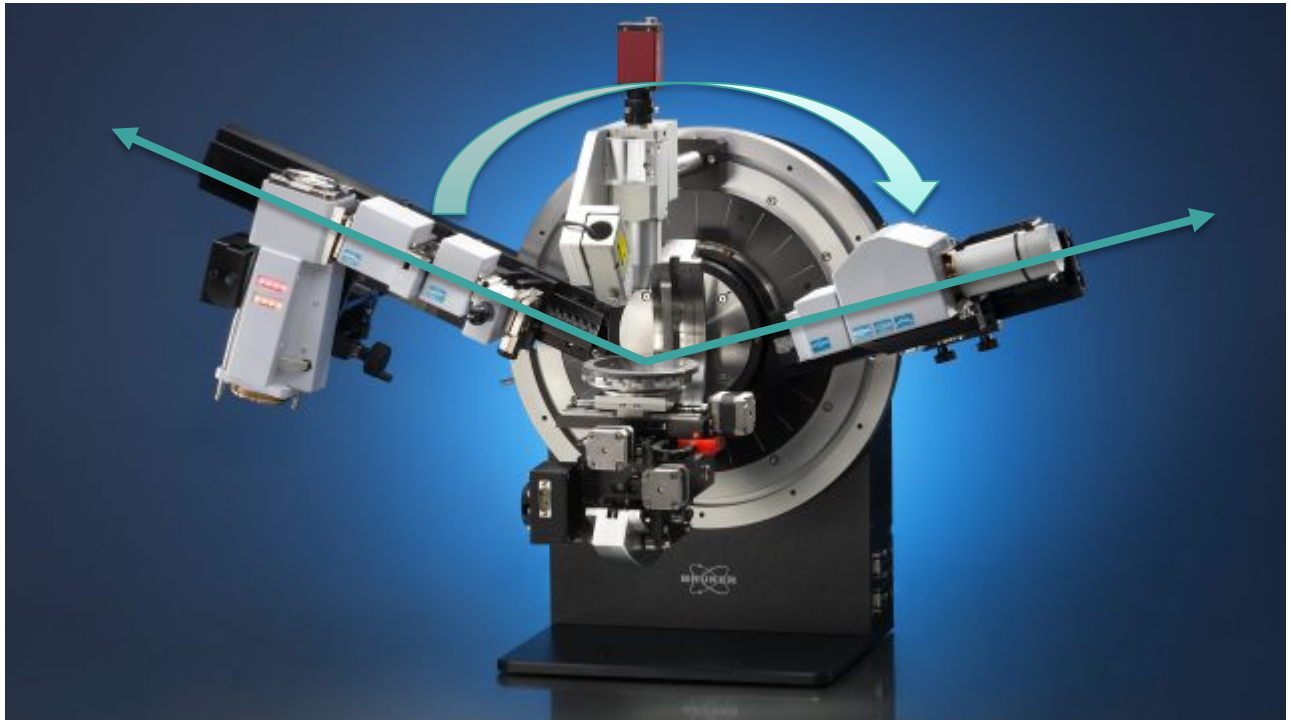


Image: Bruker

X-Ray Detector

- XRD detector detects x-rays
- Detector measures x-ray counts or intensity
- Some detectors are 1D or 2D

Image: Malvern

Technicians for XRD

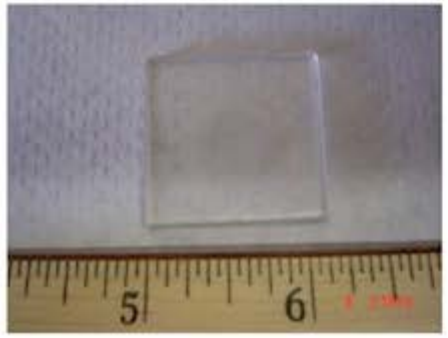
- Maintain instrument
- Prepare samples
- Mount samples
- Run samples
- Swap x-ray sources, detectors
- Confirm safe operation
- Calibration

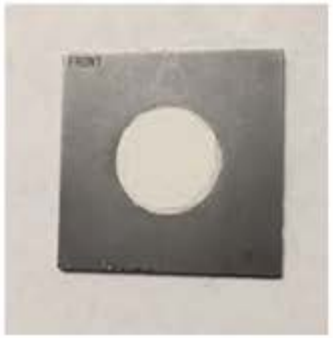
Image: Rigaku

An XRD Measurement

Video: XRD Sample Preparation

Front Load Cavity Mount





MCL
Materials Characterization Lab

Image: Penn State

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Video: XRD Sample Mount

Image: Penn State

Video: XRD Powder Diffraction

Image: Penn State

XRD Data

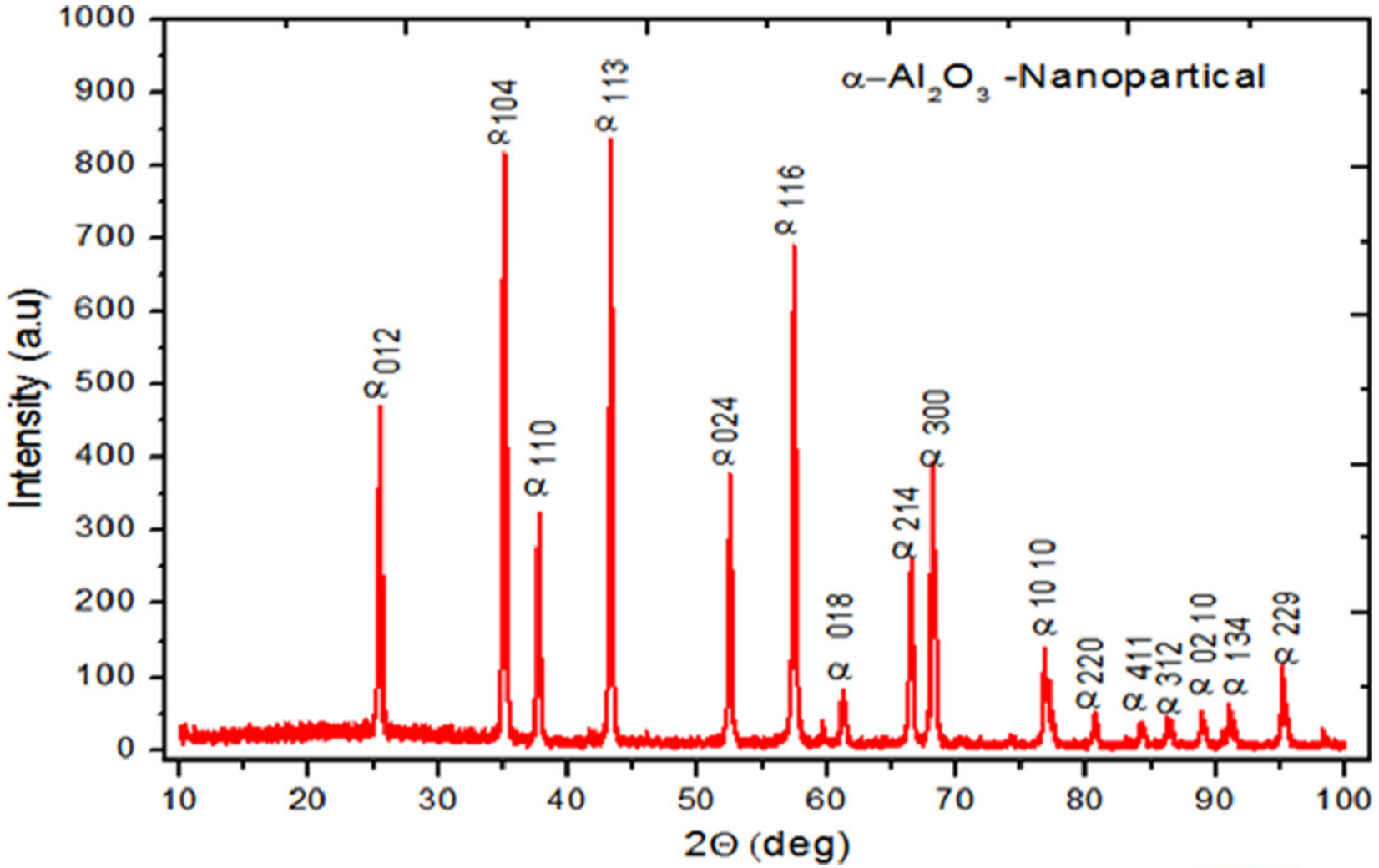

Image: Mohammed et al. DOI: 10.1016/j.cdc.2020.100531

Questions?

How could you use this in your classroom?

Building College-University Partnerships for Nanotechnology Workforce Development

Links to Resources

MNT-EC: https://micronanoeducation.org/

J ATE: https://micronanoeducation.org/journal-of-micro-nano-technology-education/

Talking Technicians: https://micronanoeducation.org/students-parents/talking-technicians-podcast/

Characterization Techniques JamBoard: https://jamboard.google.com/d/1AMKaQsB37KaWzpA51jjz5XEjmZMHGkan2K3oKYmyGIc/edit?usp=sharing

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Thanks! Please keep in touch

#teachnano

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