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# *In Situ* Diagnostics for Coated Conductor Fabrication and Characterization

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# Need for *In Situ* Diagnostics

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## Complex materials

- Among the most complicated used in industry
- Demands are high: single-crystal like structural quality
- We need all the help we can get

## Why *in situ*?

- *Ex situ* characterization can be powerful (e.g. TEM, SIMS)
- *In situ* diagnostics does the analysis where the action is, ie in the process; provides important information

BTW, we also need plenty of *ex situ* characterization!

# *In Situ* Monitoring and Diagnostics

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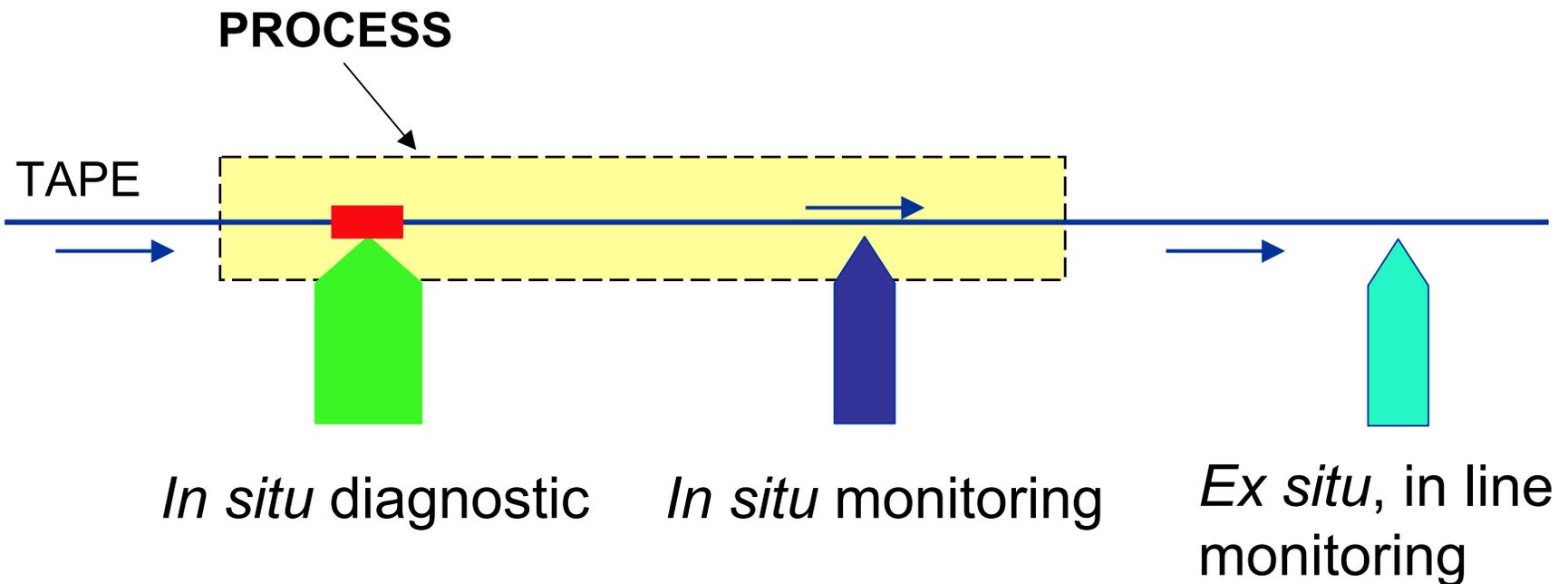
In-line (real time)

Off-line

<p>Sample property <b>monitoring</b></p>	<p><i>In situ</i> <b>diagnostics</b></p> <p>Surface analysis, composition, chemical states</p>
<p>Process parameter <b>monitoring</b></p>	

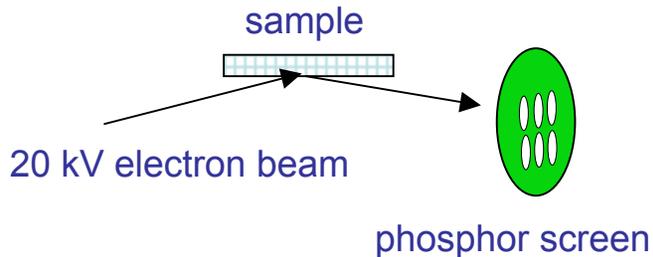
# *In Situ* Monitoring and Diagnostics

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# Example: *In-situ* RHEED is used for diagnostics of the IBAD-MgO texturing process

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RHEED provides information on:

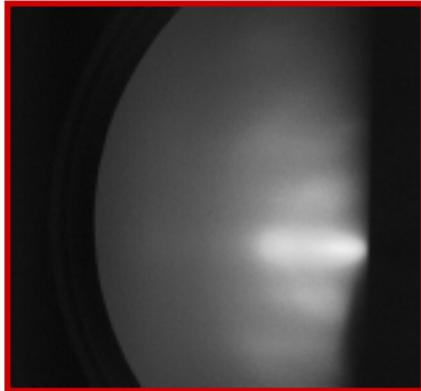
- Structure of film during growth
- Texture development (potentially quantified)
- Change of lattice parameters

QuickTime™ and a Microsoft Video 1 decompressor are needed to see this picture.

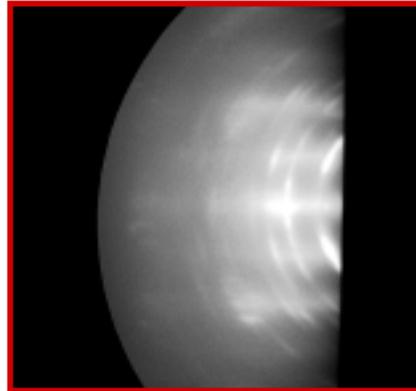
Real-time video of RHEED and diffraction pattern analysis  
IBAD-MgO on a stationary metal tape sample  
(k-Space software used for data acquisition)

# Example 2: *In situ* RHEED diagnostic on RABiTS Ni alloys - Claudia Cantoni, ORNL

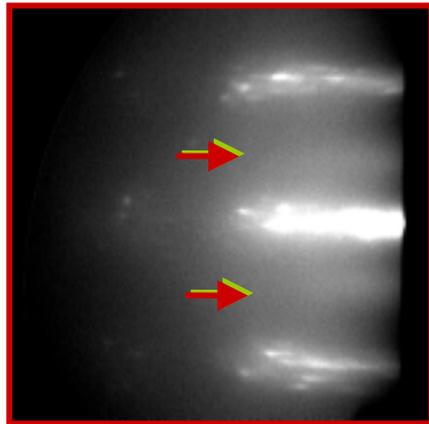
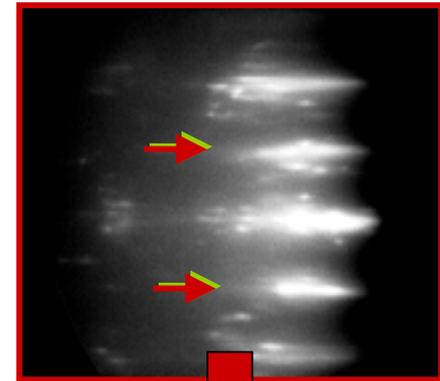
Contaminated/dirty surface



Thin polycrystalline oxide layer

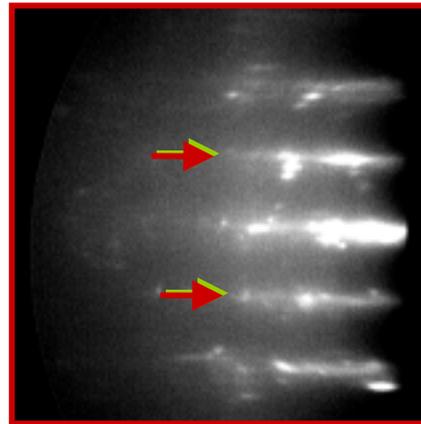


Clean surface + S superstructure

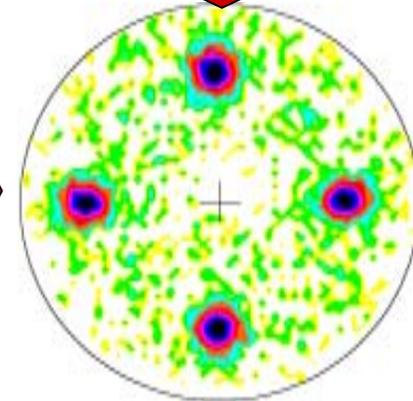
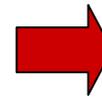


Ni surface with insufficient S content

$H_2S$

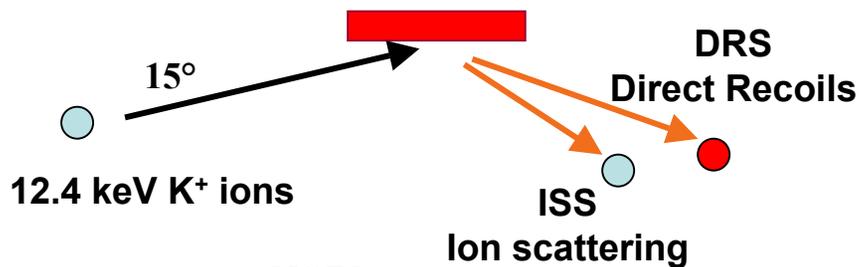


Ni surface after sulfurization, 100% S superstructure



Epitaxial seed layer

# Example 3: Time-of-Flight Ion Scattering and Recoil Spectroscopy



MSRI

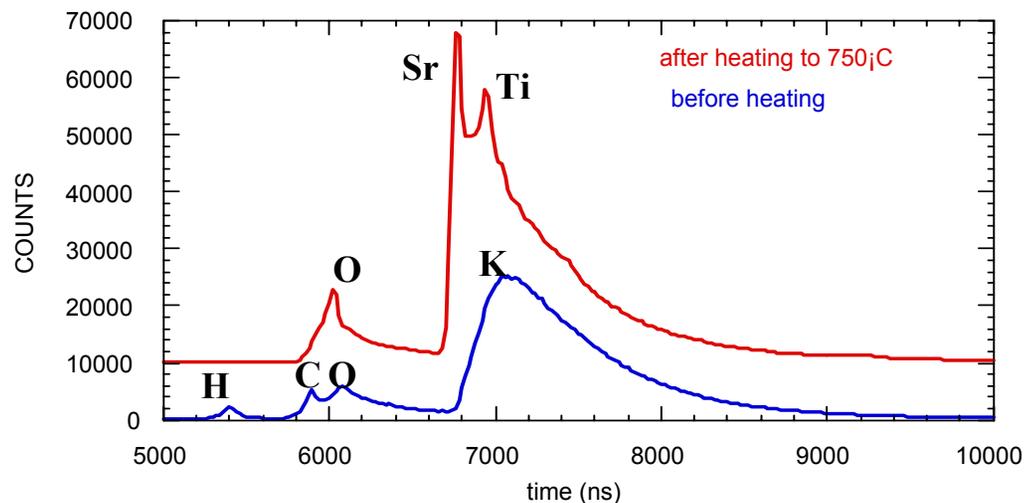
Mass Spectroscopy of Recoils

TOF-ISARS has 1-2 monolayer specificity

It is useful for determining:

- top most layers
- residues
- contamination
- complete coverage
- diffusion of elements through layers
- surface layer structure

EXAMPLE  
SrTiO<sub>3</sub> surface (DRS + ISS)



Mass Spectroscopy Sensitivity ~few ppm

# *In Situ* Monitoring and Diagnostics

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In-line (real time)

Off-line

**Sample monitoring**

RHEED, FTIR, ...

***In situ* diagnostics**

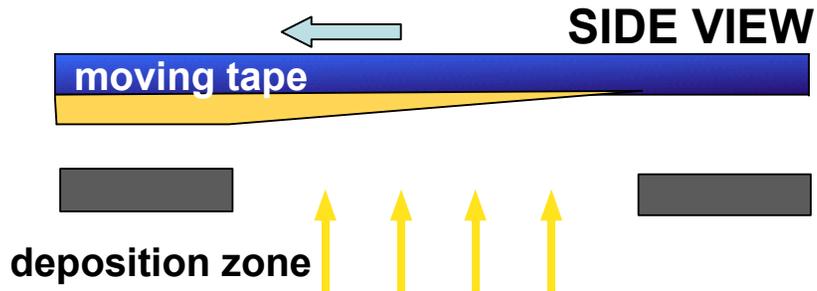
Surface analysis,  
composition

**Process monitoring**

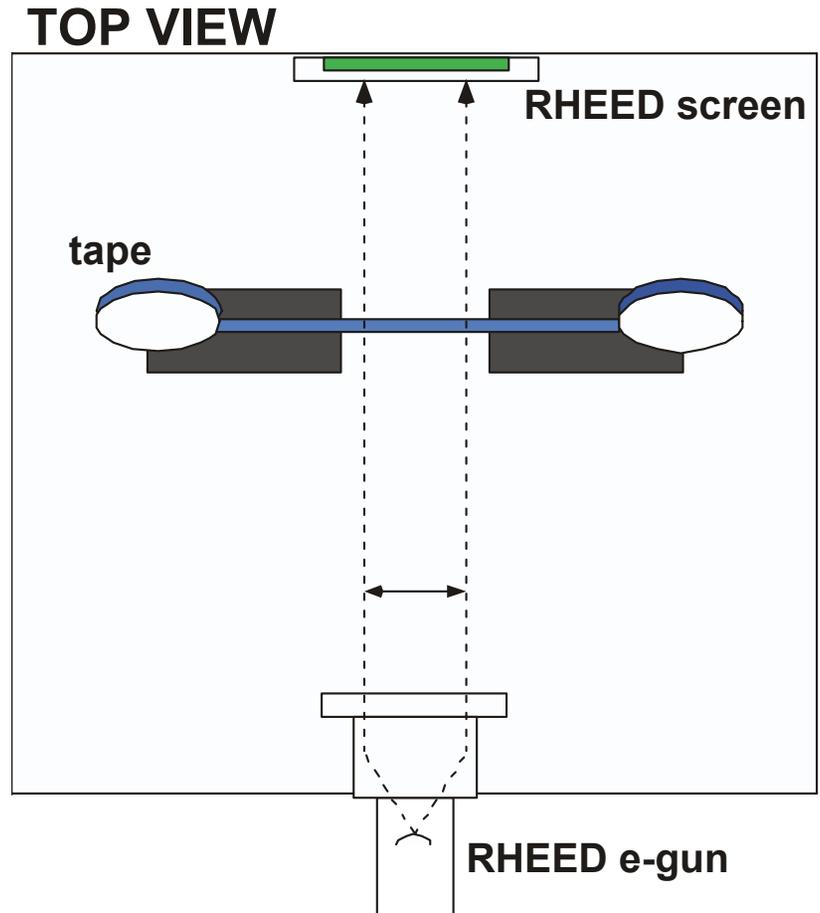
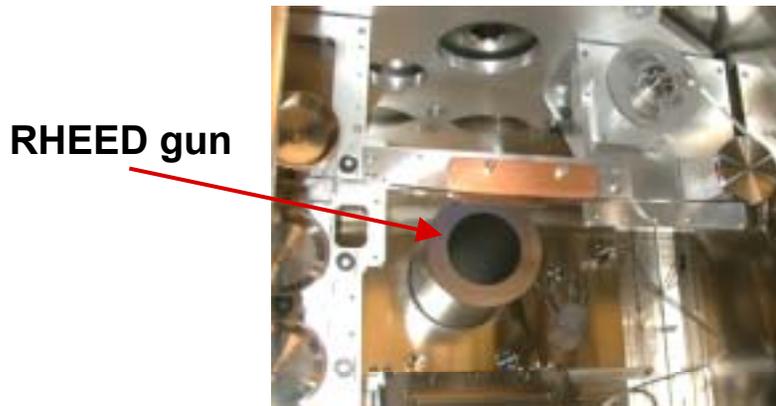
Atomic absorption, PLD  
plume monitoring, ...

RHEED, XPS, ...

# Parallel Scanning RHEED for Continuous IBAD



- By scanning the RHEED beam along the tape one obtains RHEED images at different stages of IBAD growth



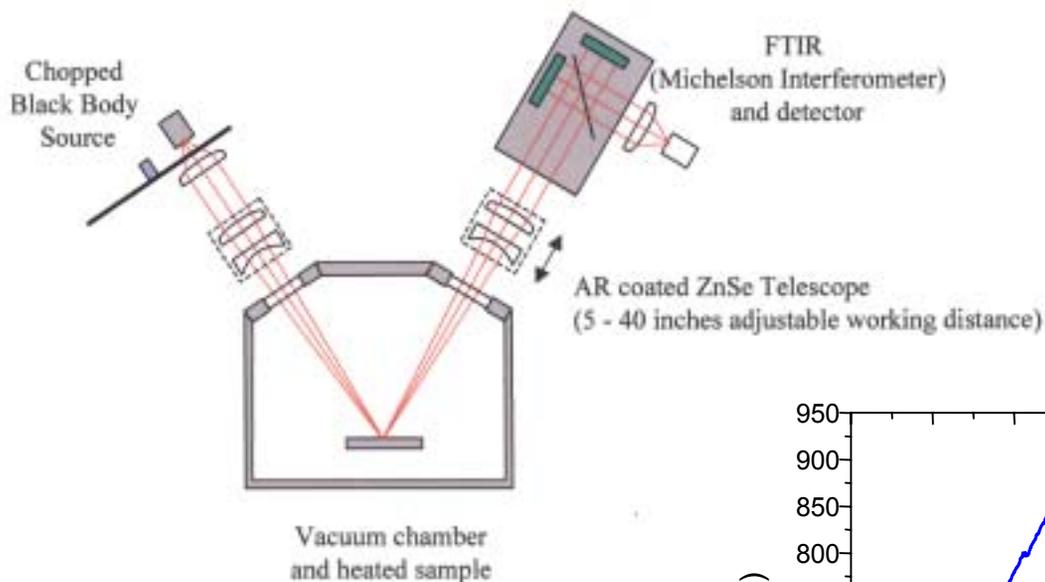
# Movie of 1 meter moving IBAD tape

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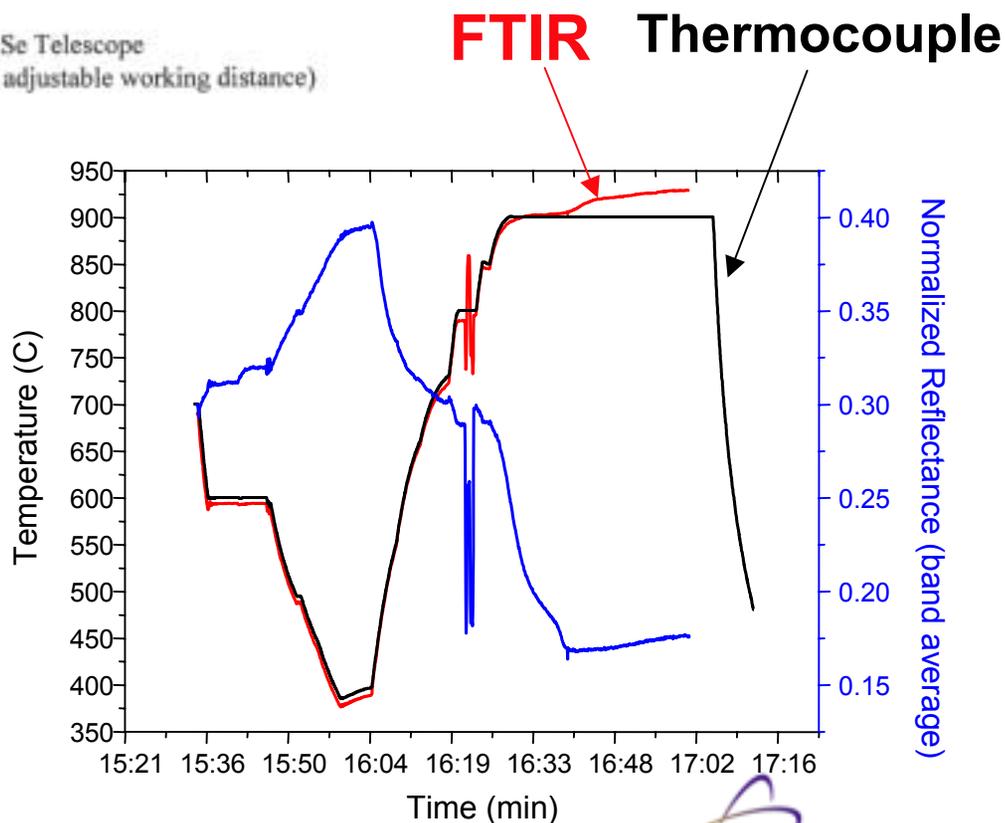
QuickTime™ and a Microsoft Video 1 decompressor are needed to see this picture.

IBAD and epi-MgO deposited continuously  
RHEED used for quality control

# Example: Fourier-Transform Infrared Spectroscopy

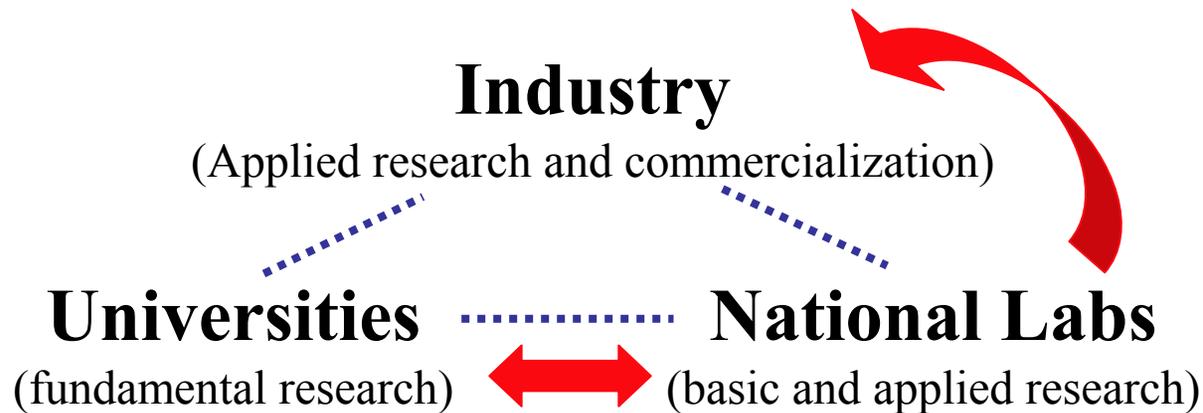


Gertjan Koster  
Hammond, Beasley  
Stanford University



# Interaction among the various parties

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- *In situ* diagnostics needs to be done in the respective labs
- Need to make use of robust *in situ* diagnostic techniques
- Need common techniques, user exchanges, transfer of knowledge for *in situ* diagnostics

# Conclusions

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- Lots of opportunities for *in situ* diagnostics
- At present lacking good characterization of surfaces and interfaces

## Topics for discussion

- What?                      What do we want to measure?
- How?                      How do we want to measure it?
- Who?                      Who can best measure?  
                                 Initiator -- end user