

# Toughness Measurement of Thin Films: What Does it Tell Us and How Reliable is That?

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# Topics

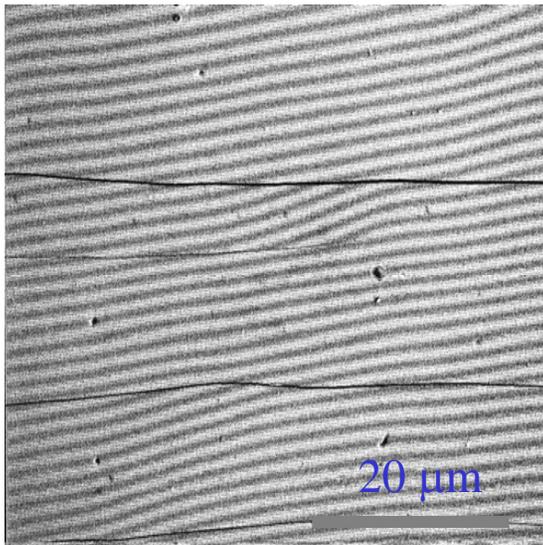
- Unusual Measurements in Mechanical Properties
- Nanoindentation

# How Does Metrology Affect your Present Work?

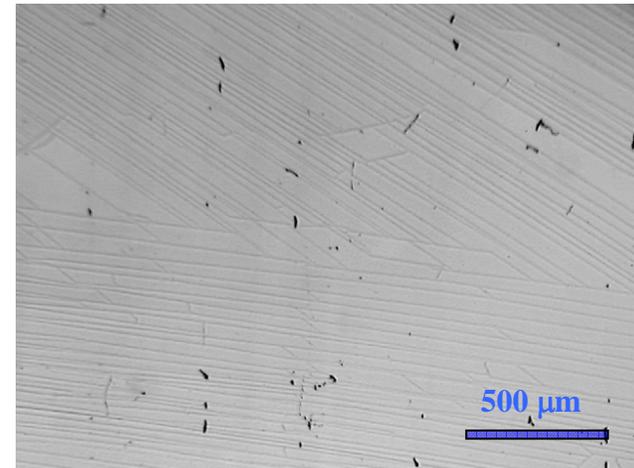
- Toughness of brittle thin films may be a useful material parameter that can be related to various material behavior (wear, handling during processing)
  - How useful can it be?
- There is no standard ( $K_C$  or  $G_C$  measurement)
  - Residual stress may dominate cracking behavior

# Two Examples Where Toughness Measurements May Help

- Design of wear-resistant films
  - Prediction of wear behavior
- Metallization for processing of solar cell film materials

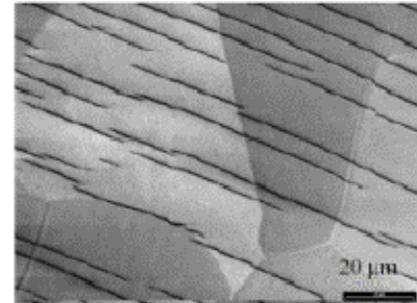
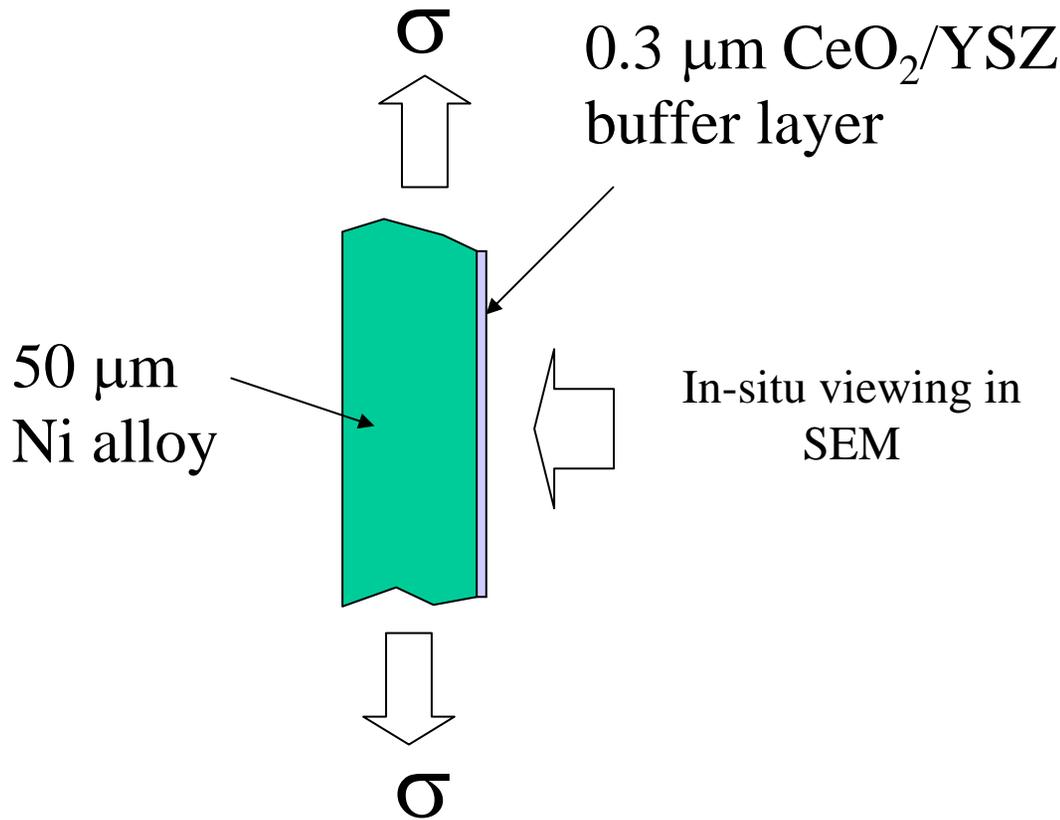


6 μm CrN film on brass

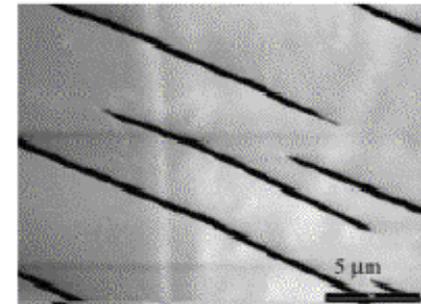


300 nm Mo film on polyimide  
Roll-on-roll technology

# Can Film Toughness be Measured?



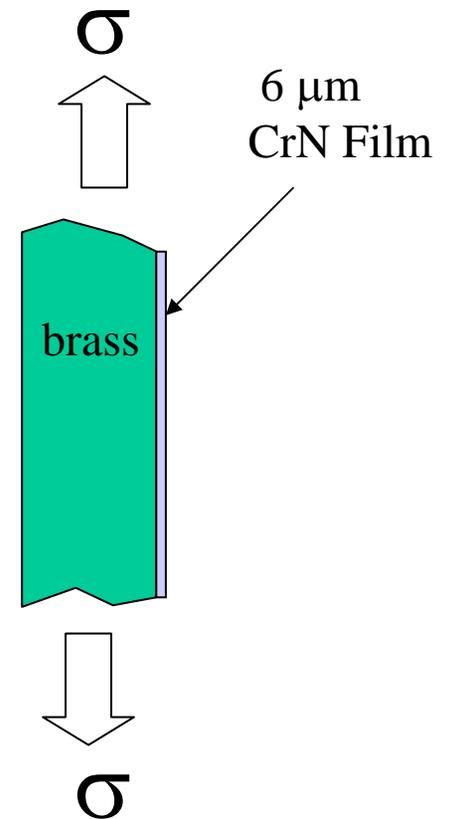
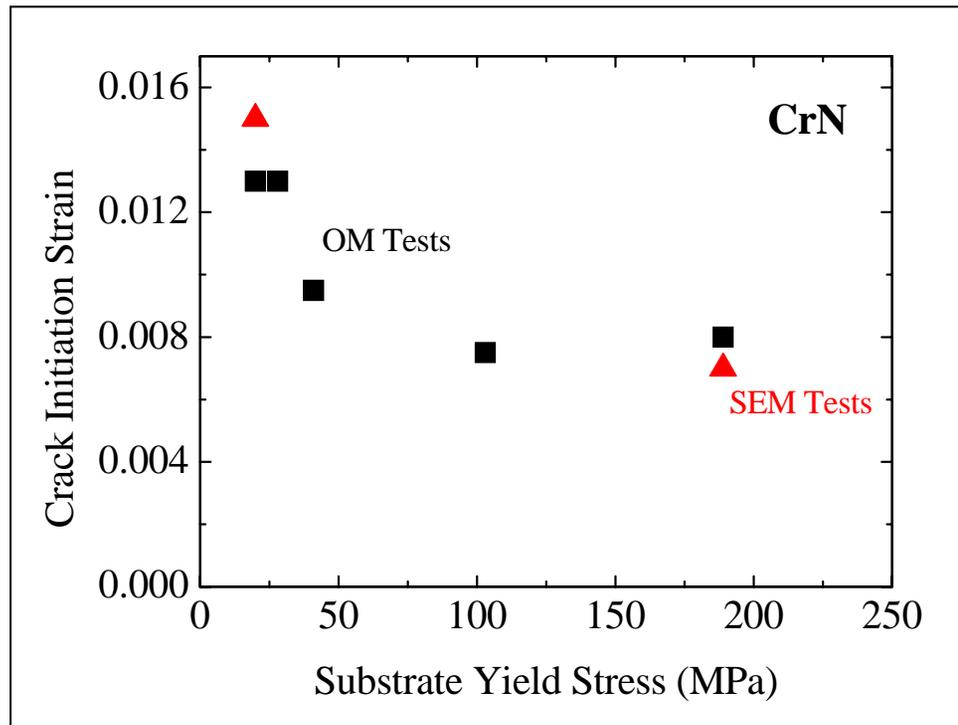
Load = 15 lbs, Mag: 1000x



Load = 15 lbs, Mag: 5000x

Experiments conducted at NIST in Boulder

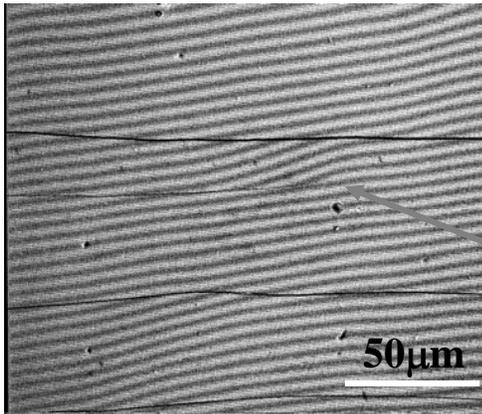
# Crack Initiation Strain in CrN



- Initiation strain decreases with increasing substrate yield stress

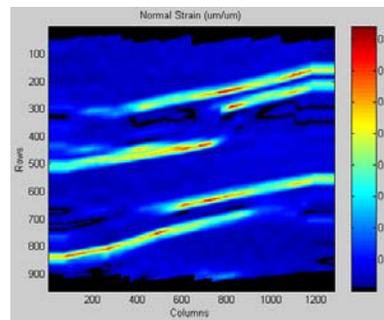
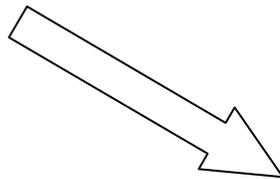
# Direct Measurement of Strain Field by E-Beam Moiré

Generate a moiré pattern in Scanning electron microscope

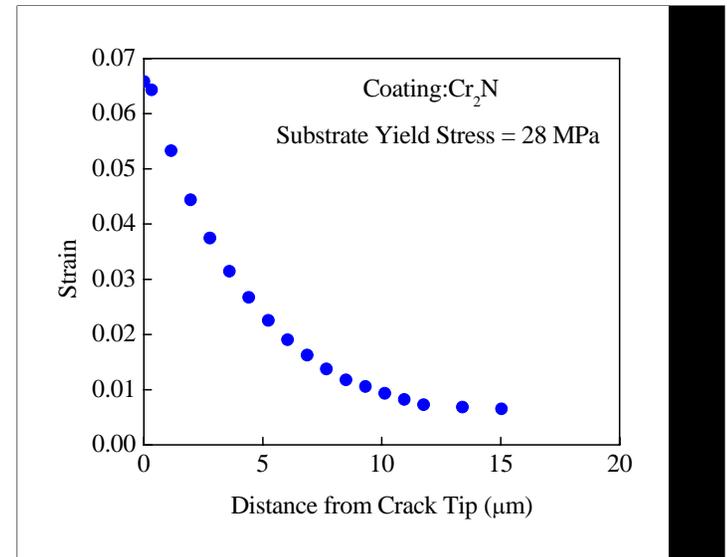


Crack Tip  
in  $\text{Cr}_2\text{N}$

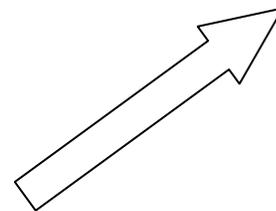
*Use Fringes to Obtain  
Displacement fields*



*Strain fields*



*Strain in front of crack tip*



Thanks to Elizabeth Drexler,  
NIST in Boulder

# How Does Metrology Affect your Present Work – a Related Topic?

- Strength and strength distribution of thin brittle films and/or multilayers
- There is no standard
- Determination of stress gradients across small dimensions
  - mechanical behavior (e.g., crack paths/prediction)
  - Diffusion of dopants/defects

# What Topic Would you Like to See Addressed?

- What are possible methods for standard measurements in a) toughness and b) strength for thin films?

# Unusual Measurements in Mechanical Properties

- Hardness increases when grains are in nanometer range
  - Is this really true?
  - What are standards for appropriate hardness ranges and to what property do they correlate?
    - E.g., armor standard hardness = 2 Kg Knoop
    - Nanometer size microstructures?