A Novel Bonding Mechanism Using Aluminum-Induced Crystallization of Amorphous Silicon

Markus D. Ong and Reinhold H. Dauskardt
Stanford University

AVS TFUG Meeting
June 20, 2007

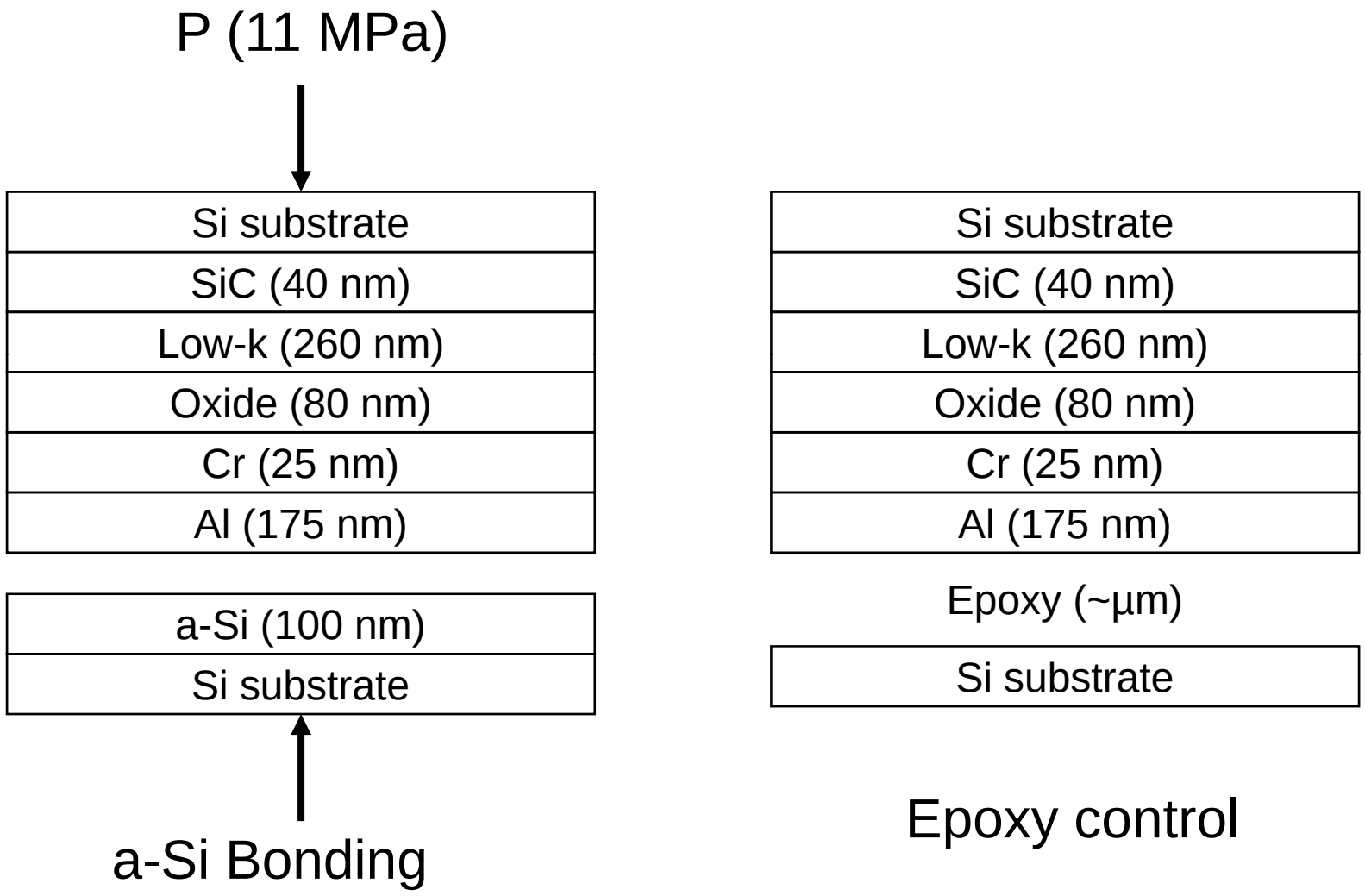
STANFORD
MATERIALS SCIENCE
AND ENGINEERING

MIC of Amorphous Si

- Metal-induced crystallization of a-Si occurs at surprisingly low temperatures
- Advantages of Al induced crystallization of a-Si as a low-T bonding technique:
  - Low T, P requirements
  - Thin bond regions
  - Strong bonds
  - Materials already commonly used in semiconductor industry

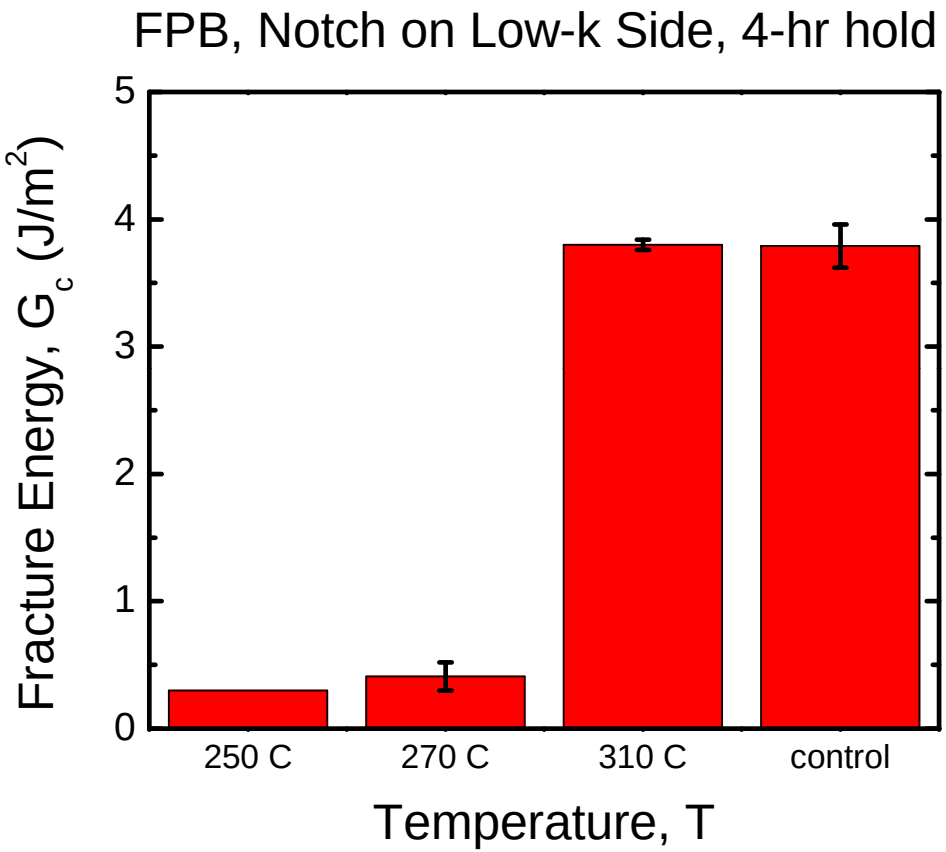
STANFORD
MATERIALS SCIENCE
AND ENGINEERING

Film Stacks



STANFORD
MATERIALS SCIENCE
AND ENGINEERING

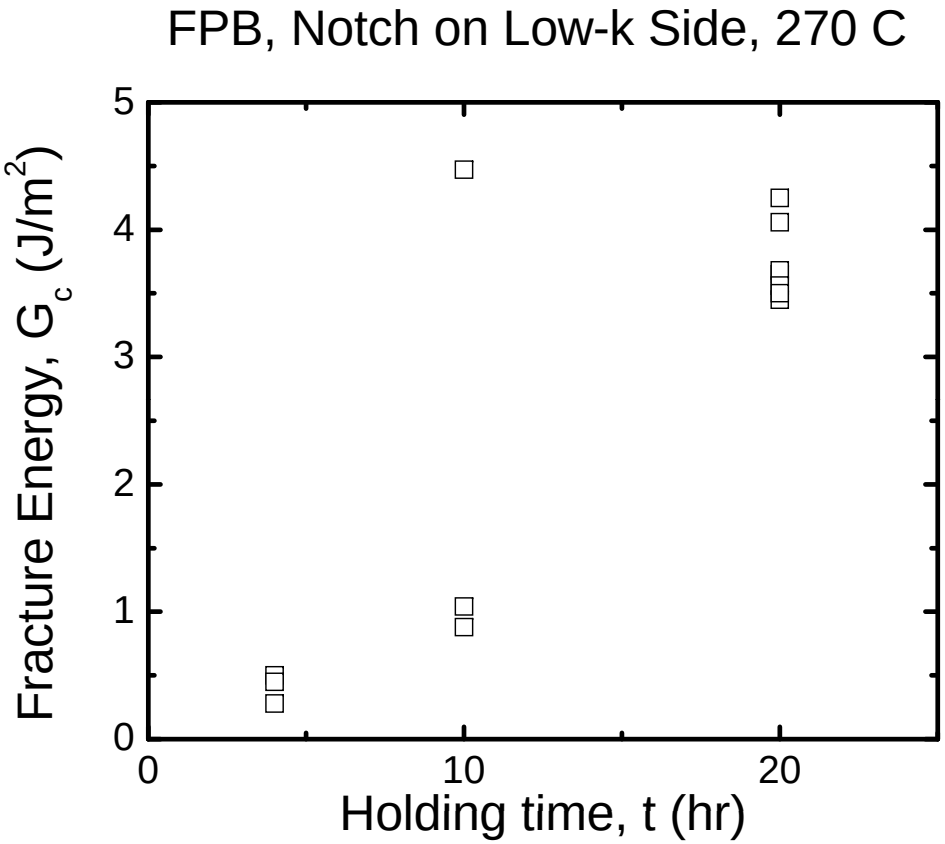
Fracture Results: FPB



Successful bonding is temperature dependent

STANFORD
MATERIALS SCIENCE
AND ENGINEERING

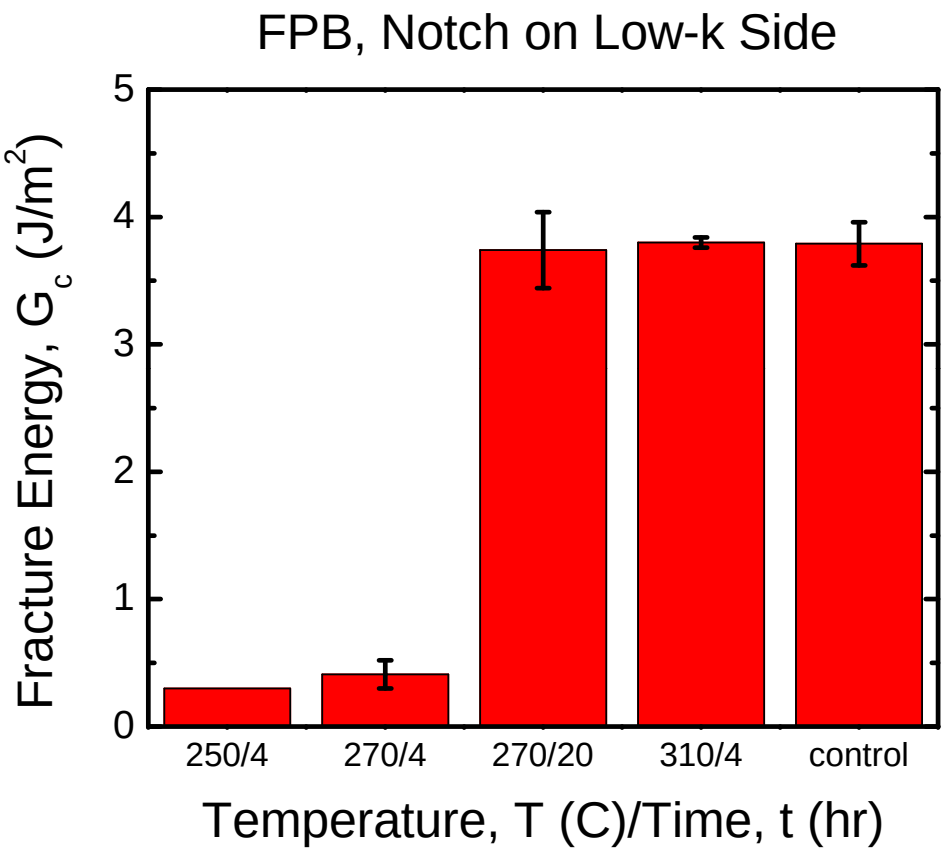
Fracture Results: FPB



Successful bonding is time dependent

STANFORD
MATERIALS SCIENCE
AND ENGINEERING

Fracture Results: FPB

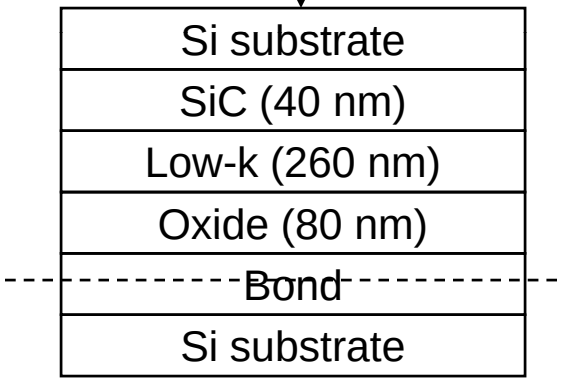


STANFORD
MATERIALS SCIENCE
AND ENGINEERING

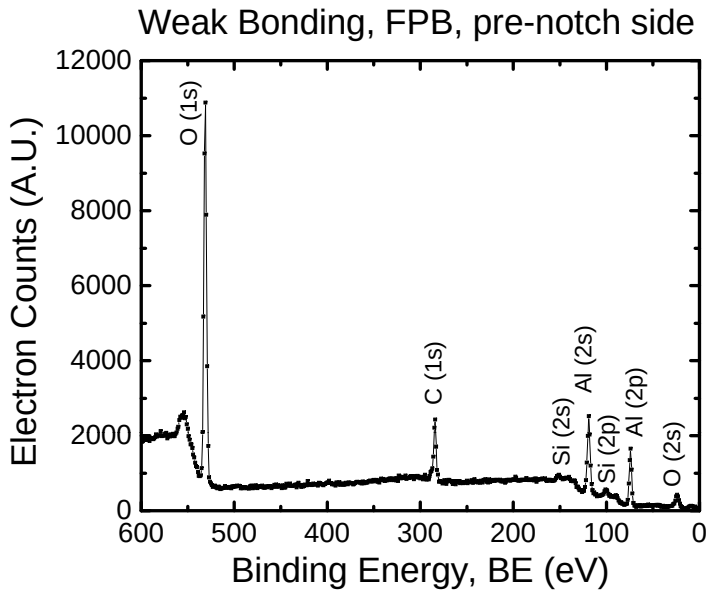
XPS, Weak Bond

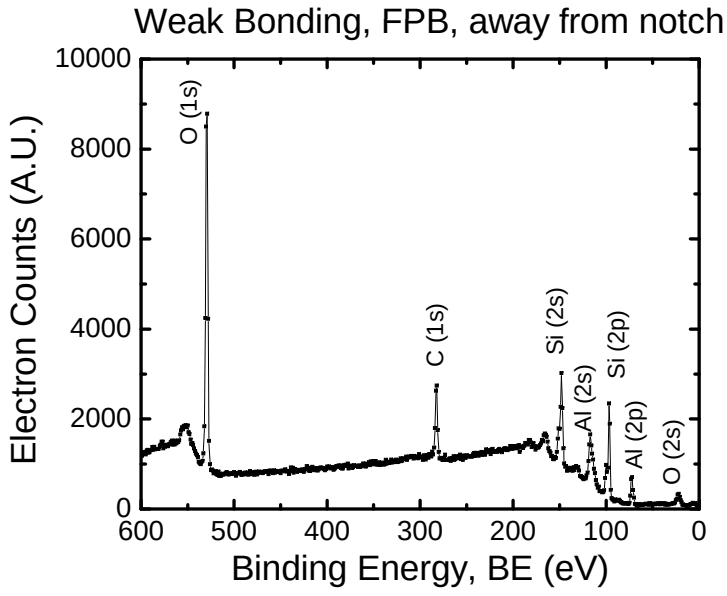
C (1s)	19
Si (2p)	4
O (1s)	47
Al (2p)	30

Pre-notch



C (1s)	21
Si (2p)	28
O (1s)	38
Al (2p)	12



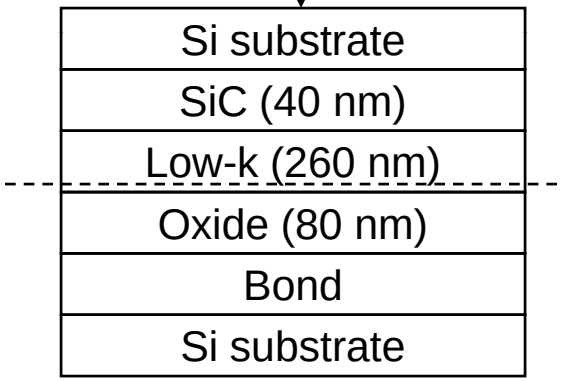


STANFORD
MATERIALS SCIENCE
AND ENGINEERING

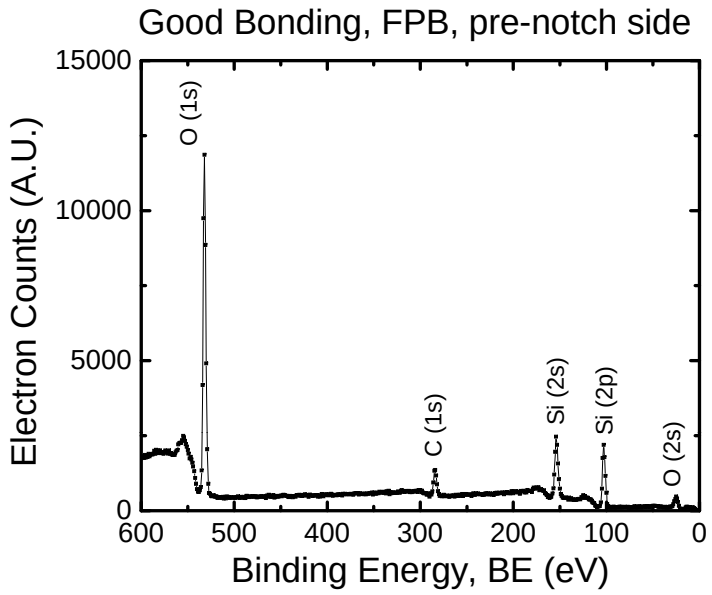
XPS, Successful Bond

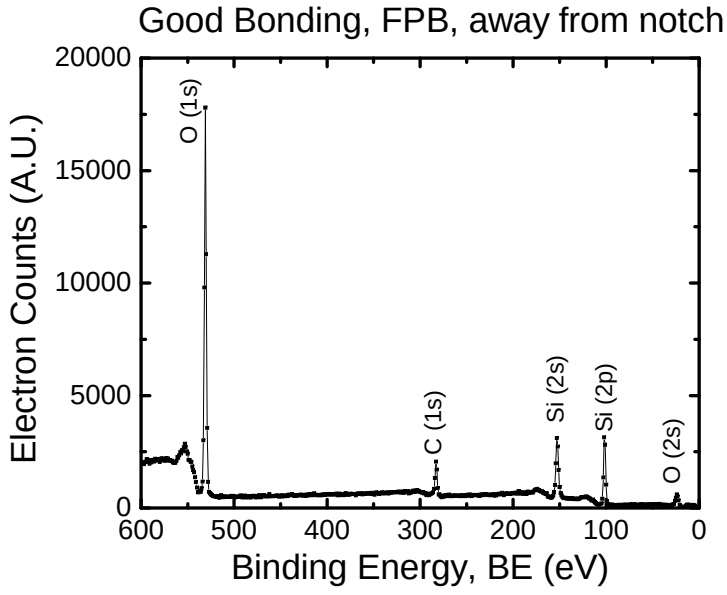
C (1s)	12
Si (2p)	31
O (1s)	57

Pre-notch



C (1s)	14
Si (2p)	29
O (1s)	56





STANFORD
MATERIALS SCIENCE
AND ENGINEERING

Depth Profile

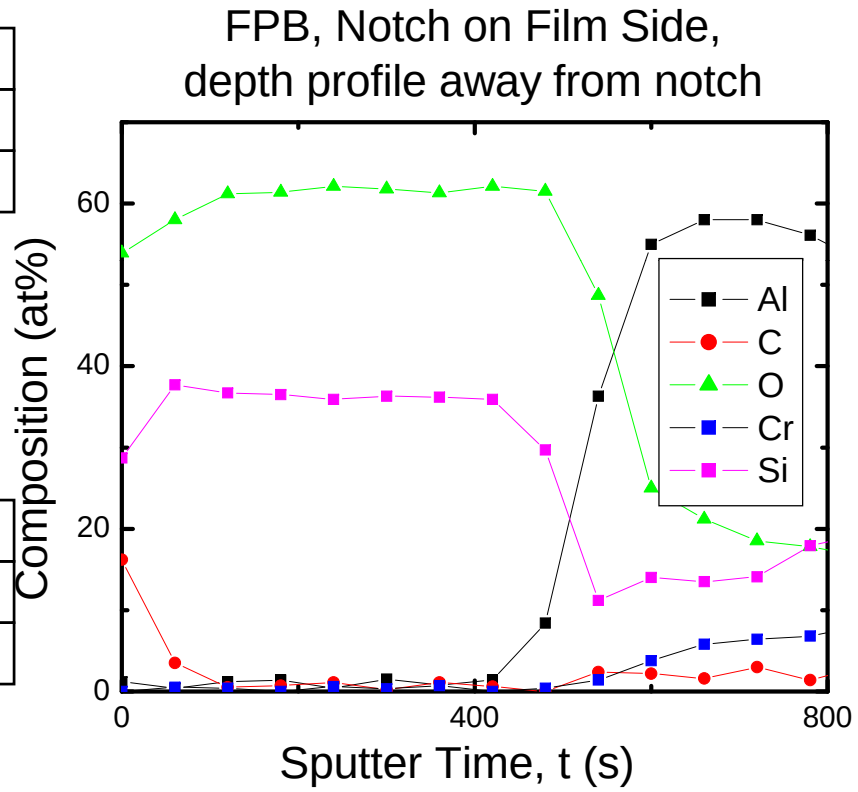
C (1s)	12
Si (2p)	31
O (1s)	57

Si substrate
SiC (40 nm)
Low-k (260 nm)

Etch

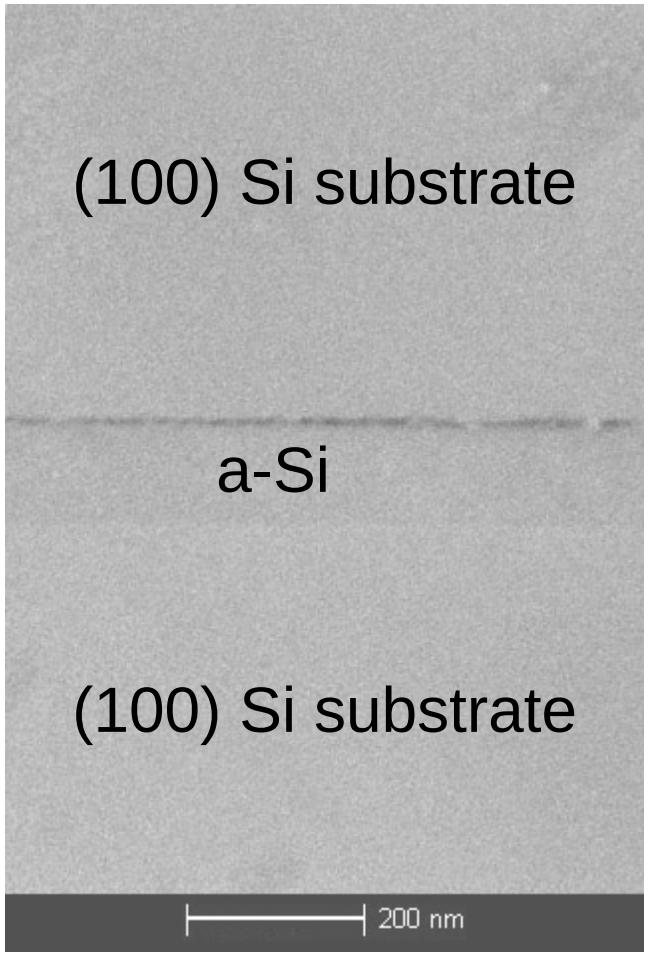
C (1s)	14
Si (2p)	29
O (1s)	56

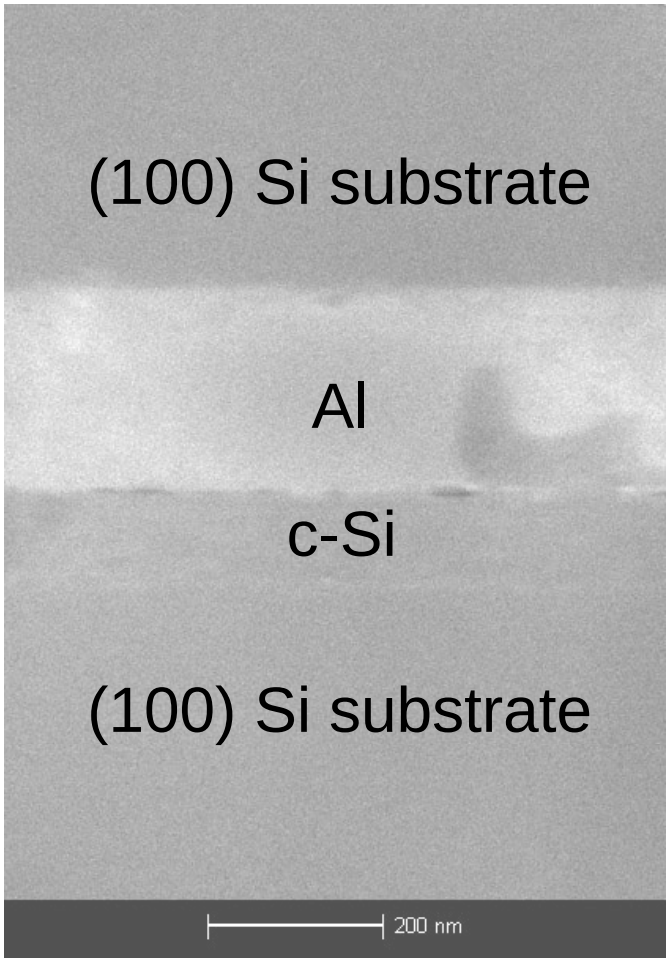
Oxide (80 nm)
Bond
Si substrate



STANFORD
MATERIALS SCIENCE
AND ENGINEERING

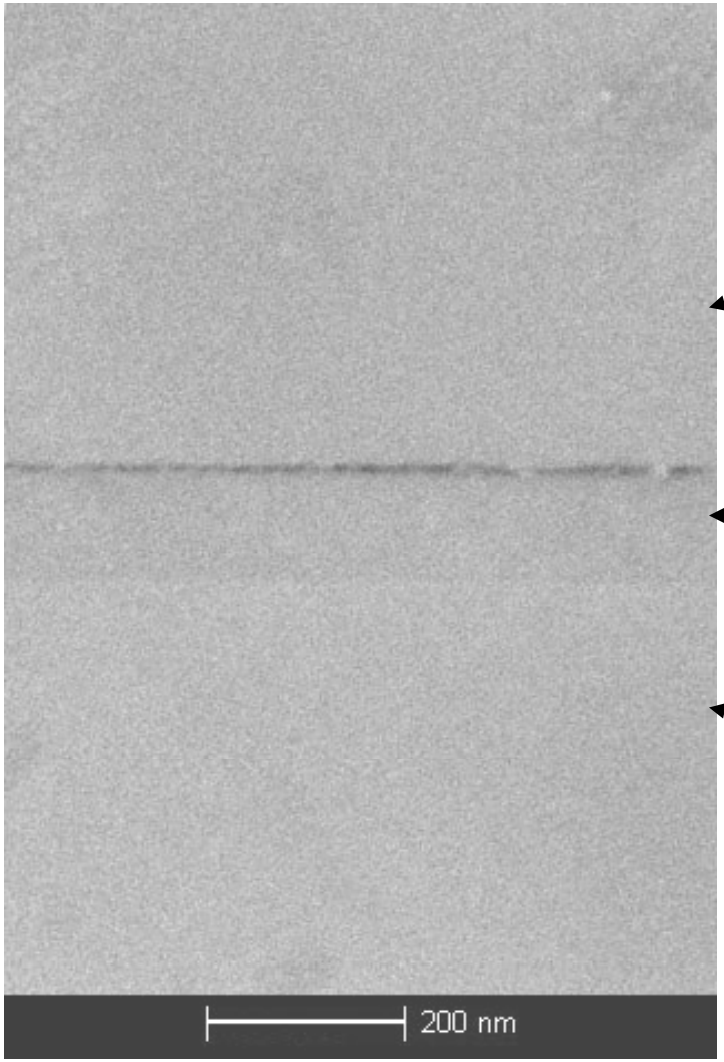
SEM Characterization





STANFORD
MATERIALS SCIENCE
AND ENGINEERING

Electron Backscatter Diffraction

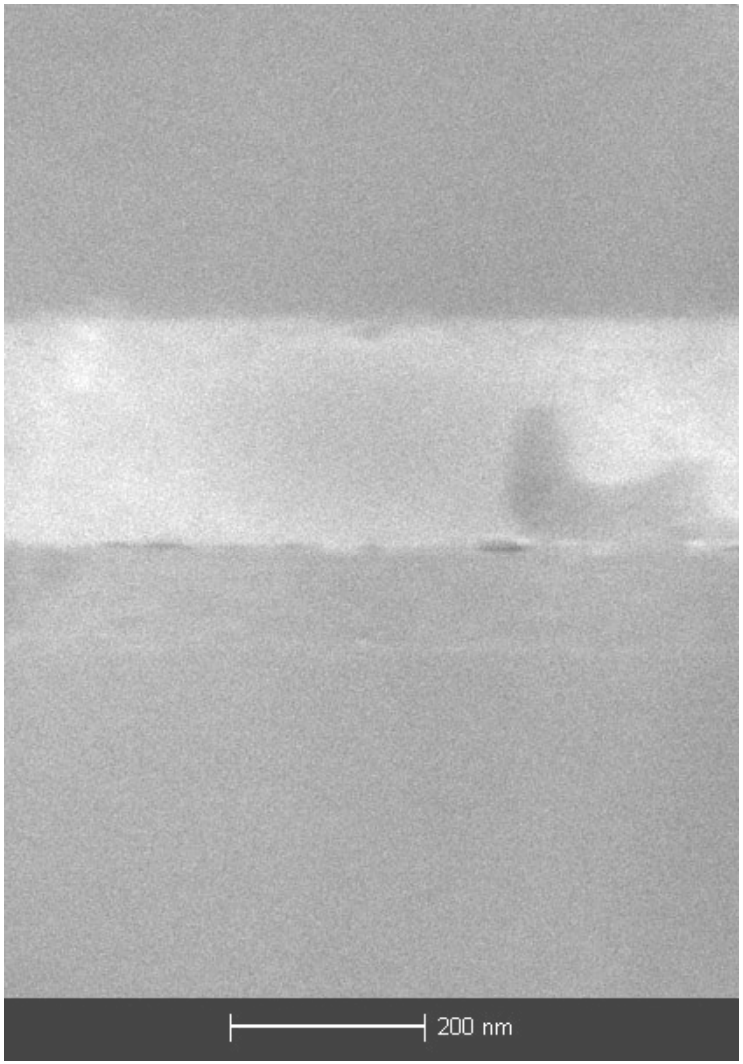


Strong c-Si pattern

Pattern fades out,
indicating a-Si region

Strong c-Si pattern

Electron Backscatter Diffraction



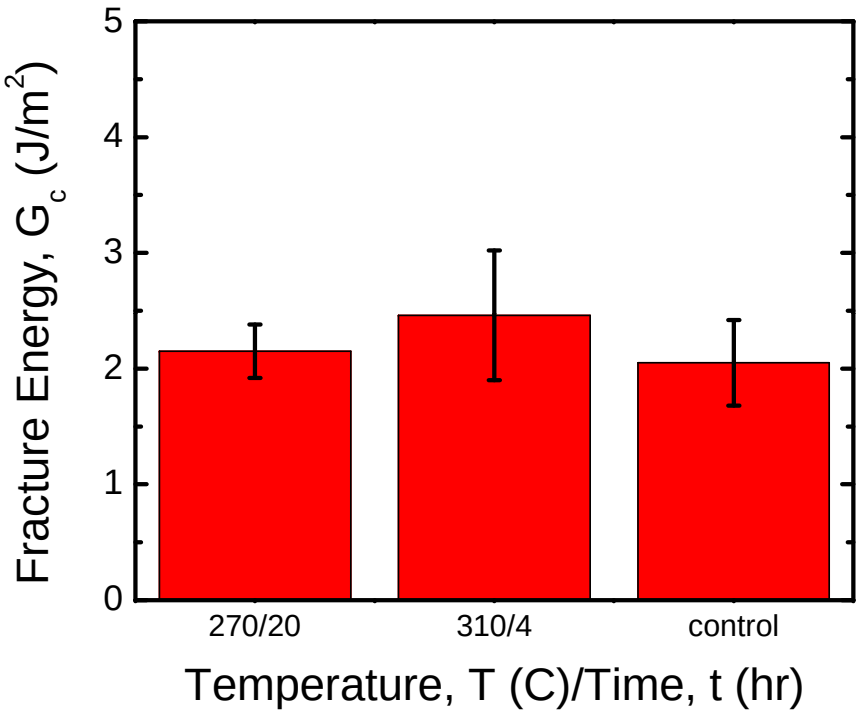
Strong (unsolved) pattern, should be Al

Strong c-Si pattern retained

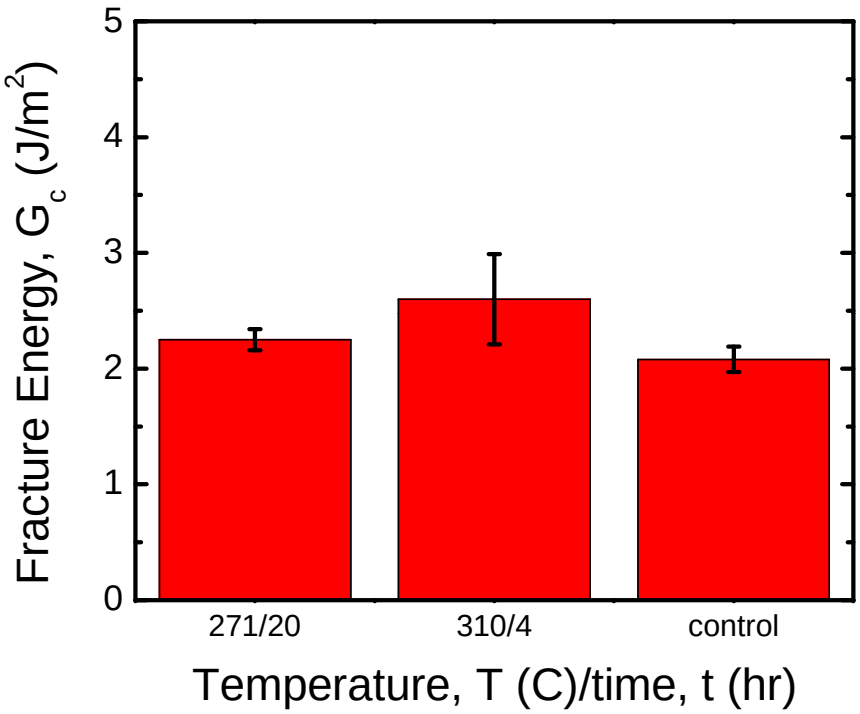
Strong c-Si pattern

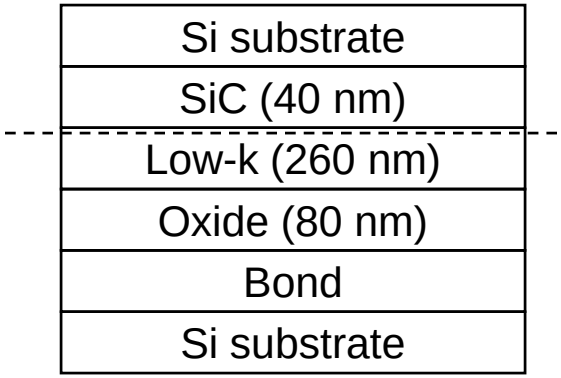
Other Fracture Geometries

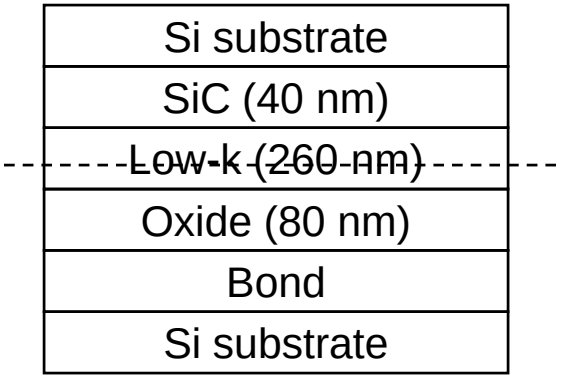
FPB, Notch on Blank Side



Double Cantilever Beam

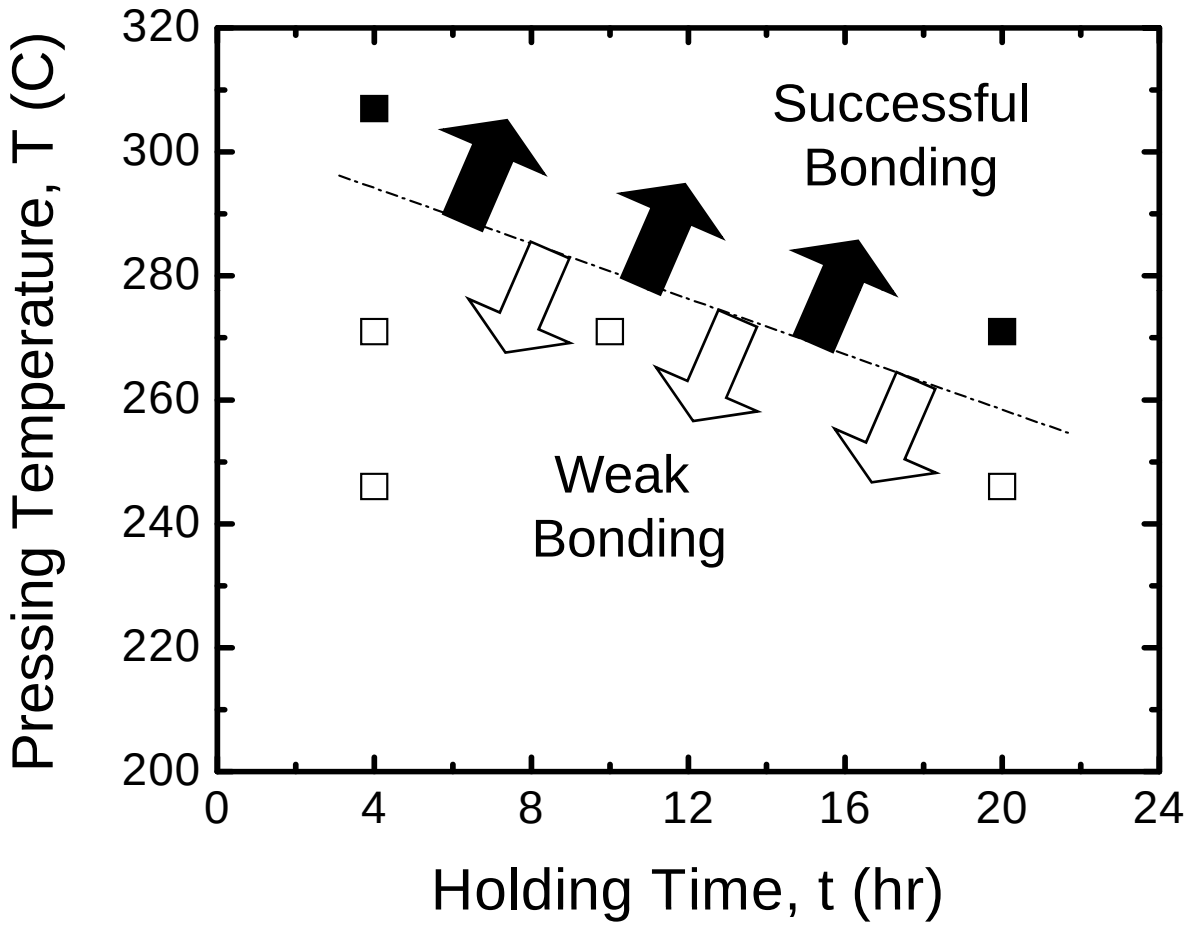






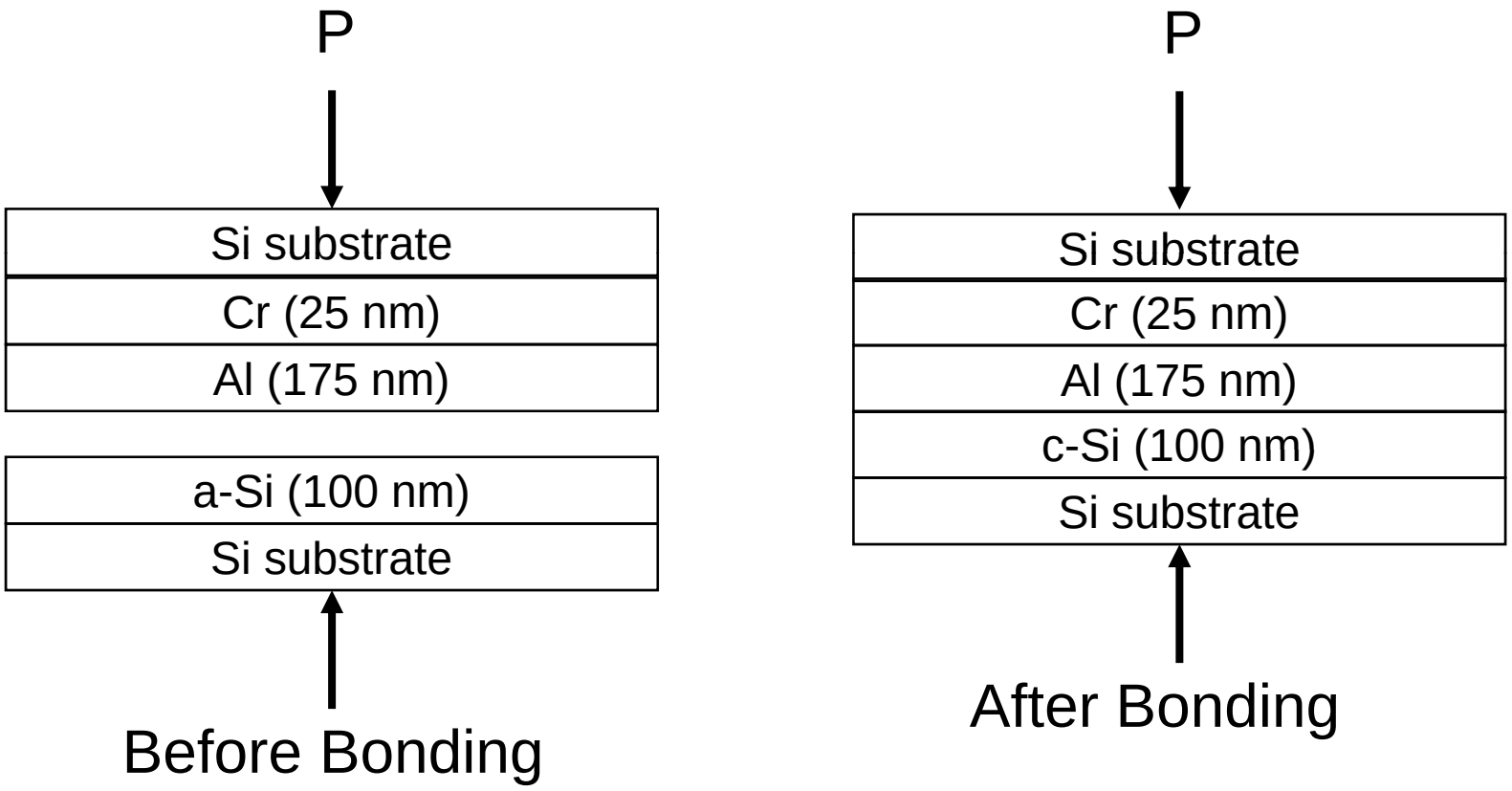
STANFORD
MATERIALS SCIENCE
AND ENGINEERING

Time/Temperature Dependence



STANFORD
MATERIALS SCIENCE AND ENGINEERING

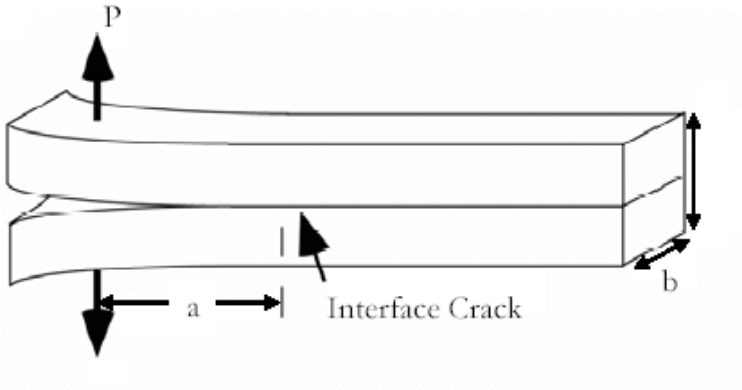
Film Stacks, no low-k

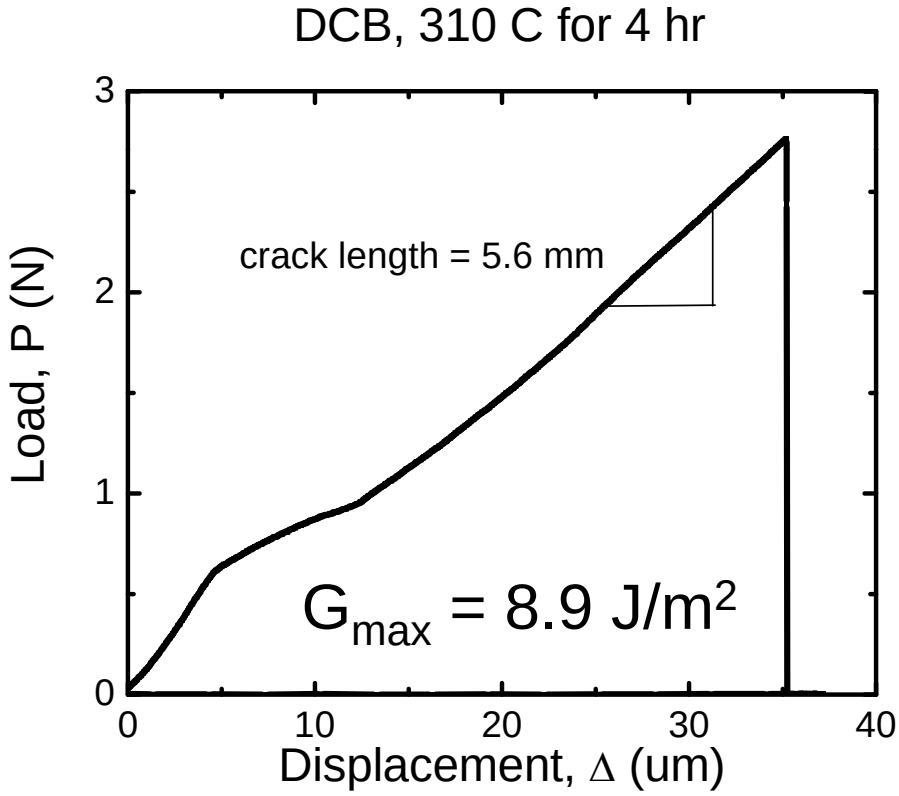


STANFORD
MATERIALS SCIENCE
AND ENGINEERING

Bond Strength Fracture Tests

Strong bond makes measuring fracture energies difficult

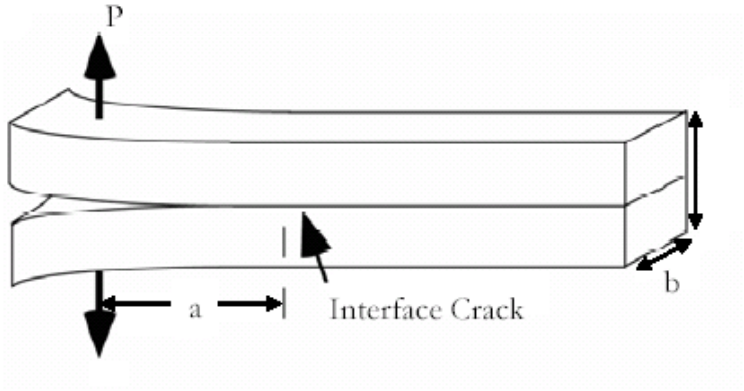




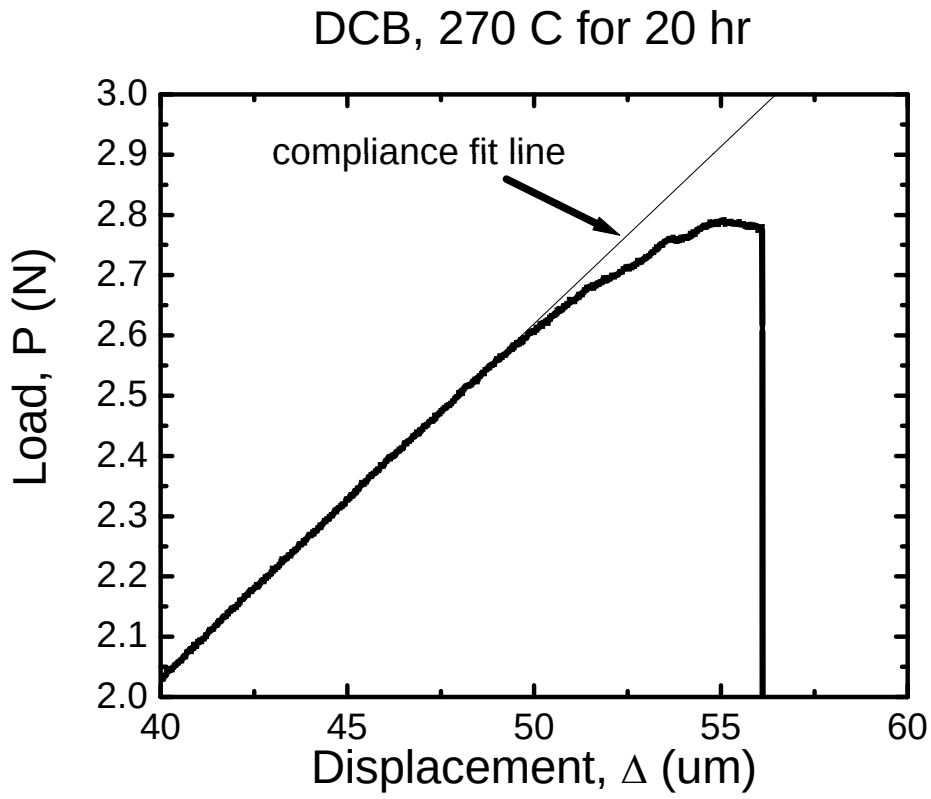
STANFORD
MATERIALS SCIENCE
AND ENGINEERING

Bond Strength Fracture Tests

Strong bond makes measuring fracture energies difficult



Test	Applied G (J/m^2)
1	*12.0*
2	10.4
3	*11.2*



STANFORD
MATERIALS SCIENCE
AND ENGINEERING

Conclusions

- MIC of a-Si can be exploited to form strong, thin bonds at low temperatures
- Successful bonding is dependent on both pressing time and temperature
- Bond regions and crystallization coincide with Al depositions
- Fracture energies of the bond are around 10 J/m^2

STANFORD
MATERIALS SCIENCE
AND ENGINEERING