

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

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AVS TFUG Meeting
June 20, 2007

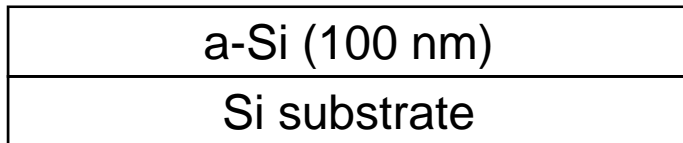
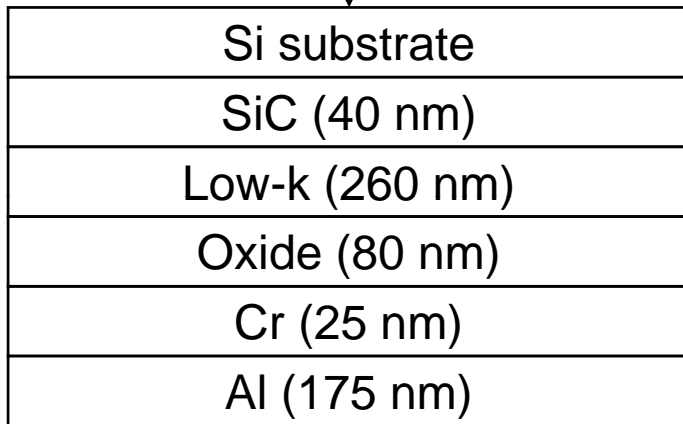


MIC of Amorphous Si

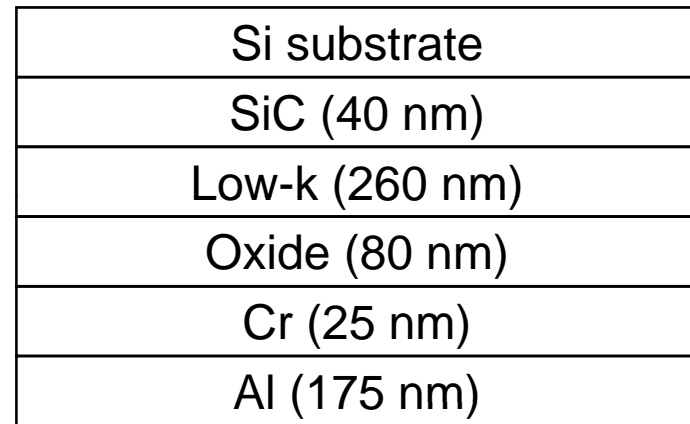
- Metal-induced crystallization of a-Si occurs at surprisingly low temperatures
- Advantages of Al induced crystallization of a-Si as a low-T bonding technique:
 - Low T, P requirements
 - Thin bond regions
 - Strong bonds
 - Materials already commonly used in semiconductor industry

Film Stacks

P (11 MPa)



a-Si Bonding

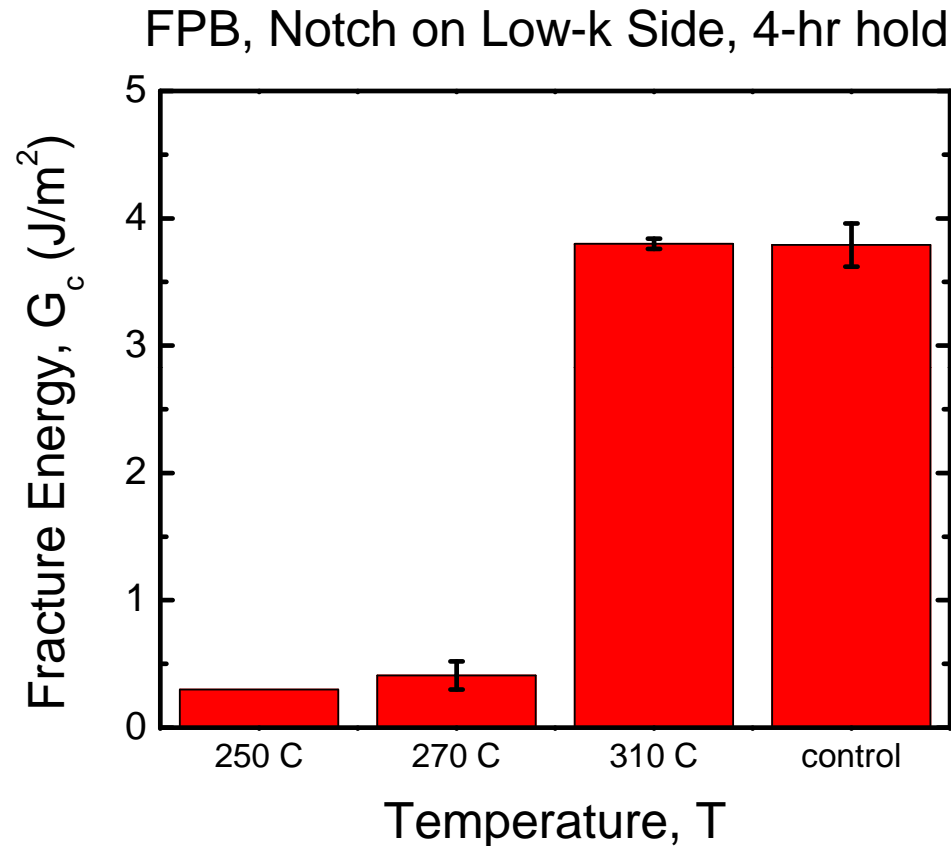


Epoxy (~ μm)



Epoxy control

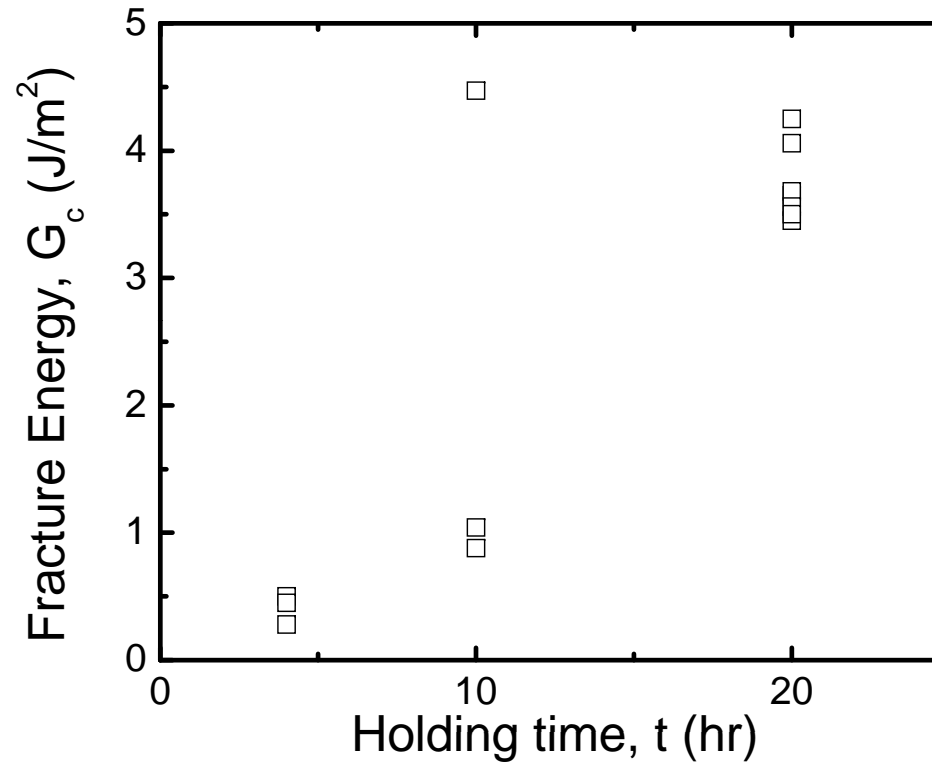
Fracture Results: FPB



Successful bonding is temperature dependent

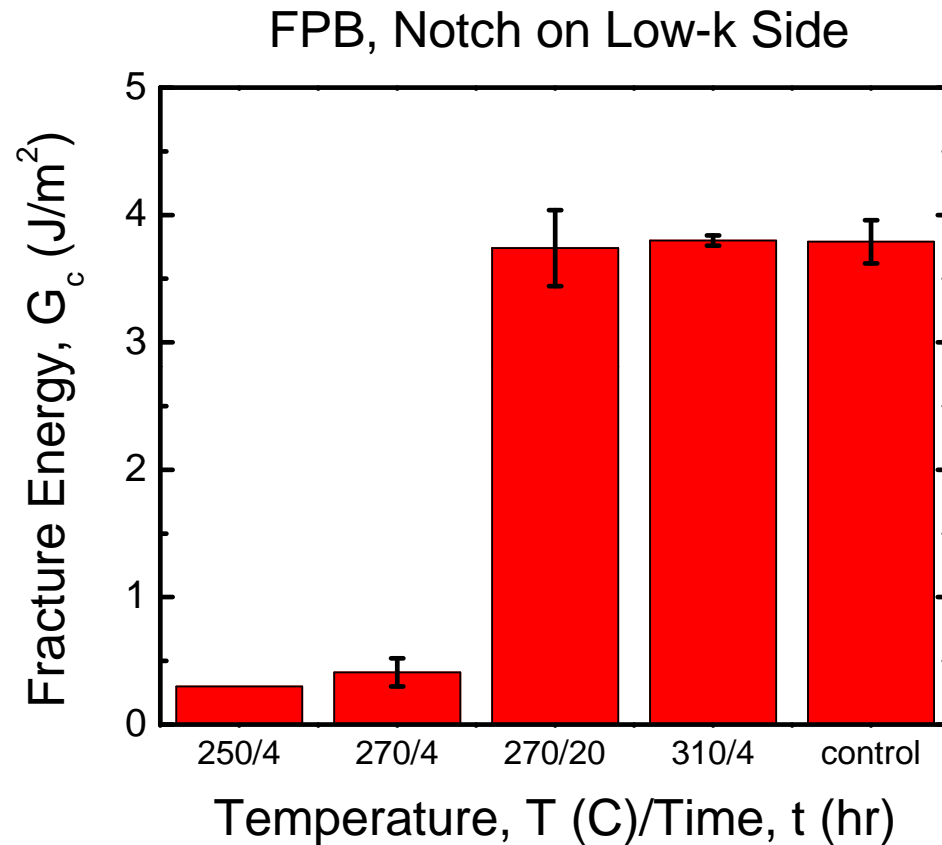
Fracture Results: FPB

FPB, Notch on Low-k Side, 270 C



Successful bonding is time dependent

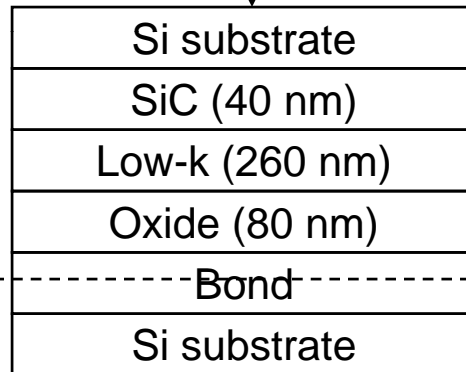
Fracture Results: FPB



XPS, Weak Bond

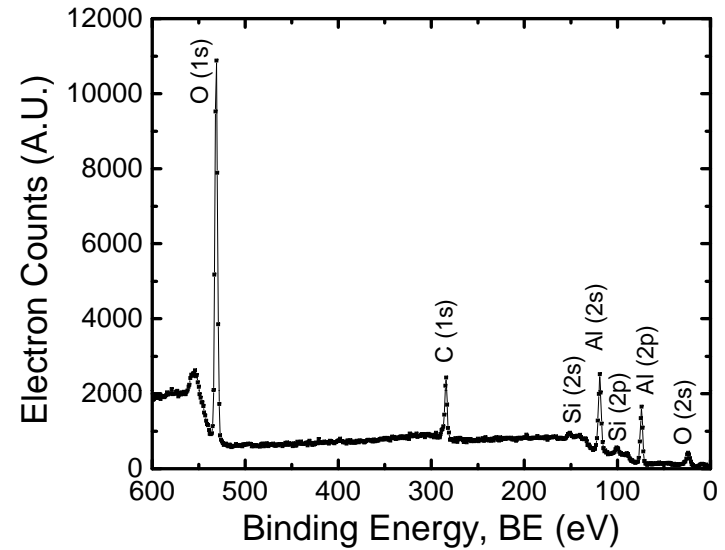
C (1s)	19
Si (2p)	4
O (1s)	47
Al (2p)	30

Pre-notch

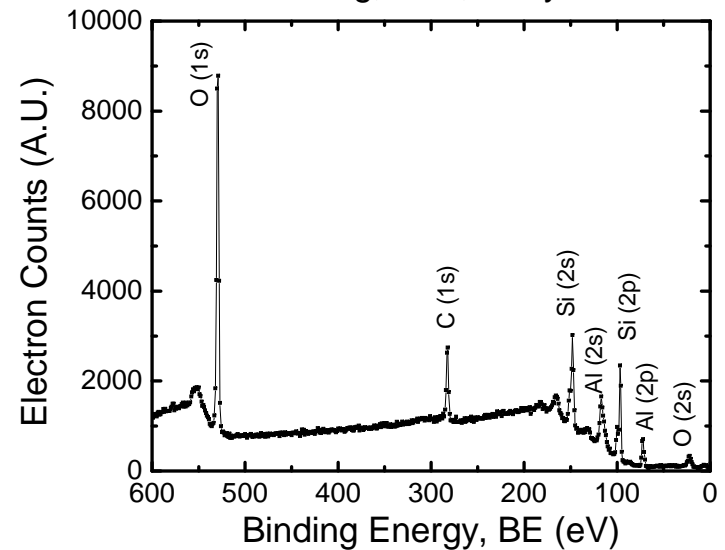


C (1s)	21
Si (2p)	28
O (1s)	38
Al (2p)	12

Weak Bonding, FPB, pre-notch side



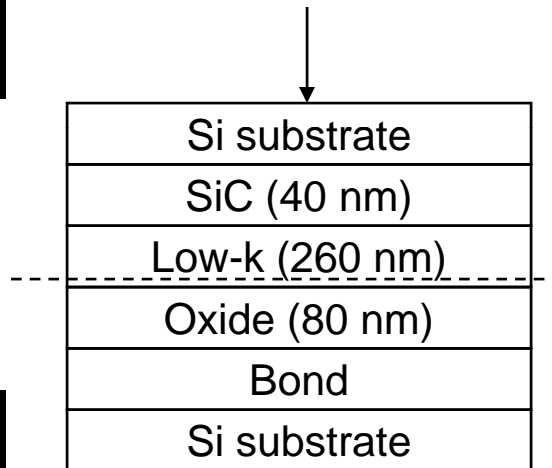
Weak Bonding, FPB, away from notch



XPS, Successful Bond

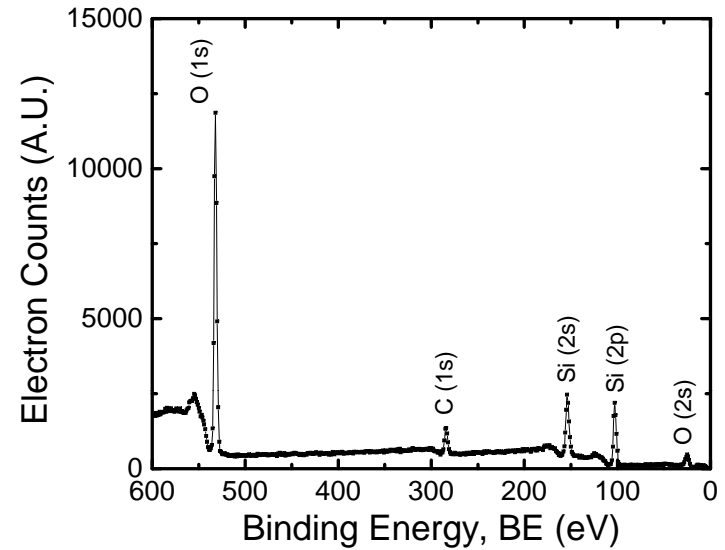
C (1s)	12
Si (2p)	31
O (1s)	57

Pre-notch

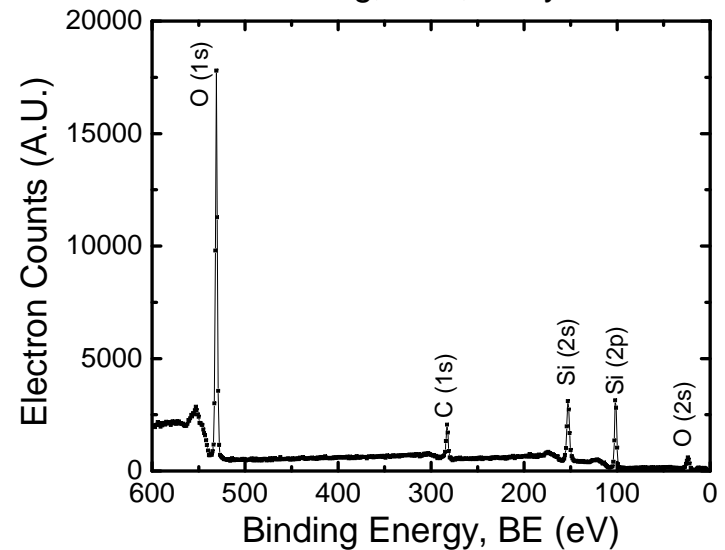


C (1s)	14
Si (2p)	29
O (1s)	56

Good Bonding, FPB, pre-notch side



Good Bonding, FPB, away from notch



Depth Profile

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

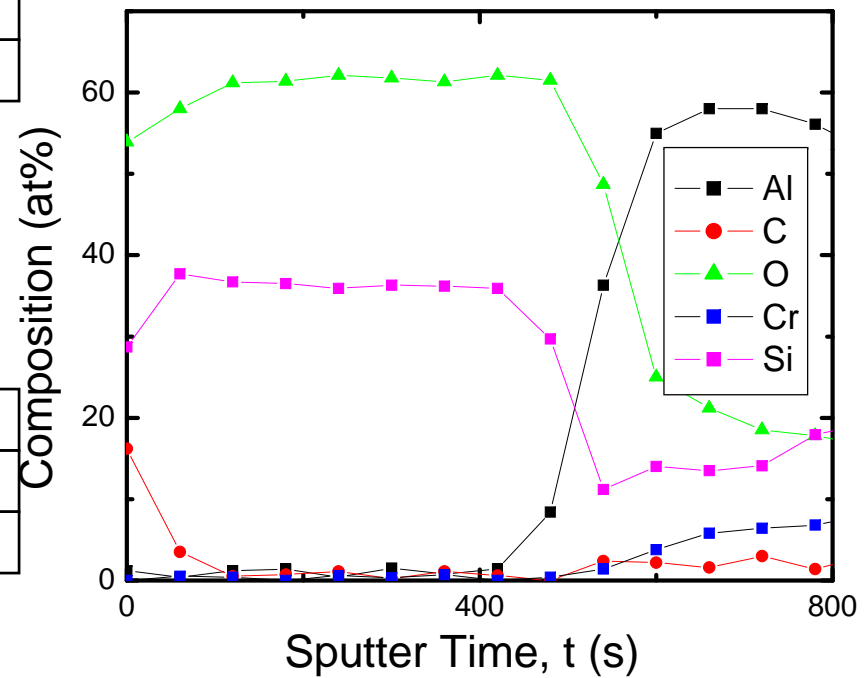
Si substrate
SiC (40 nm)
Low-k (260 nm)

Etch

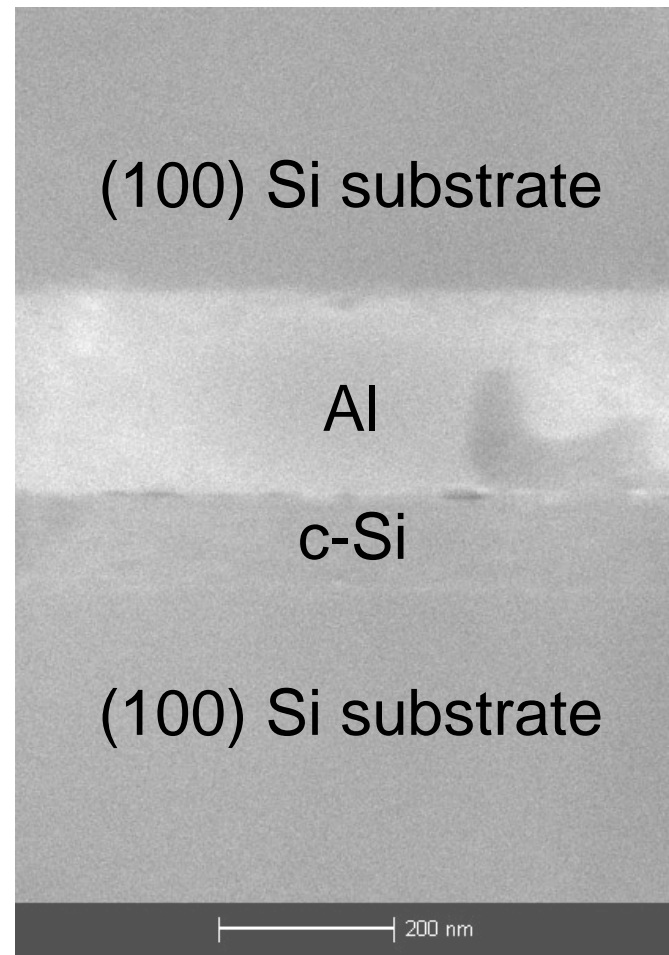
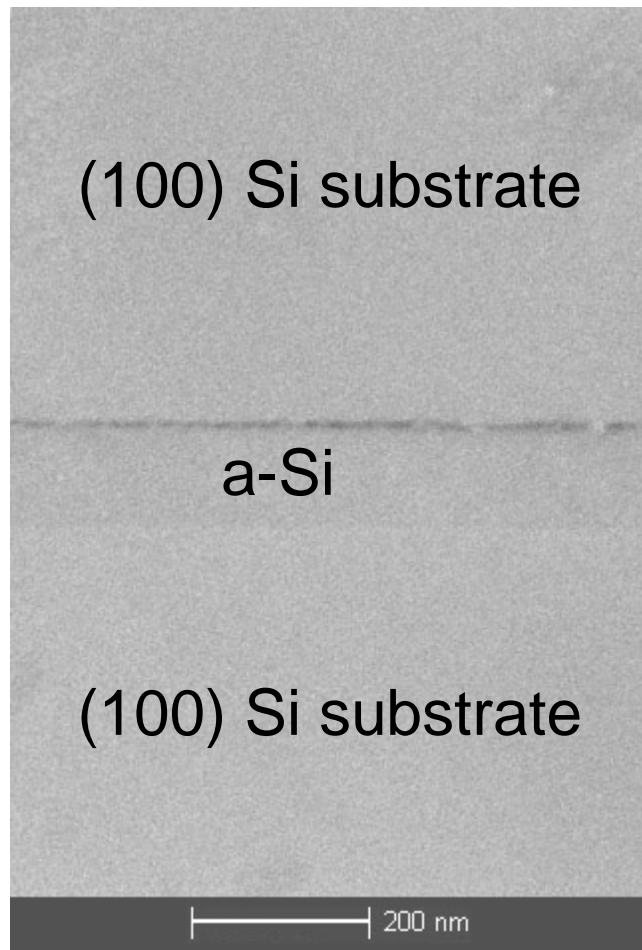
C (1s)	14
Si (2p)	29
O (1s)	56

Oxide (80 nm)
Bond
Si substrate

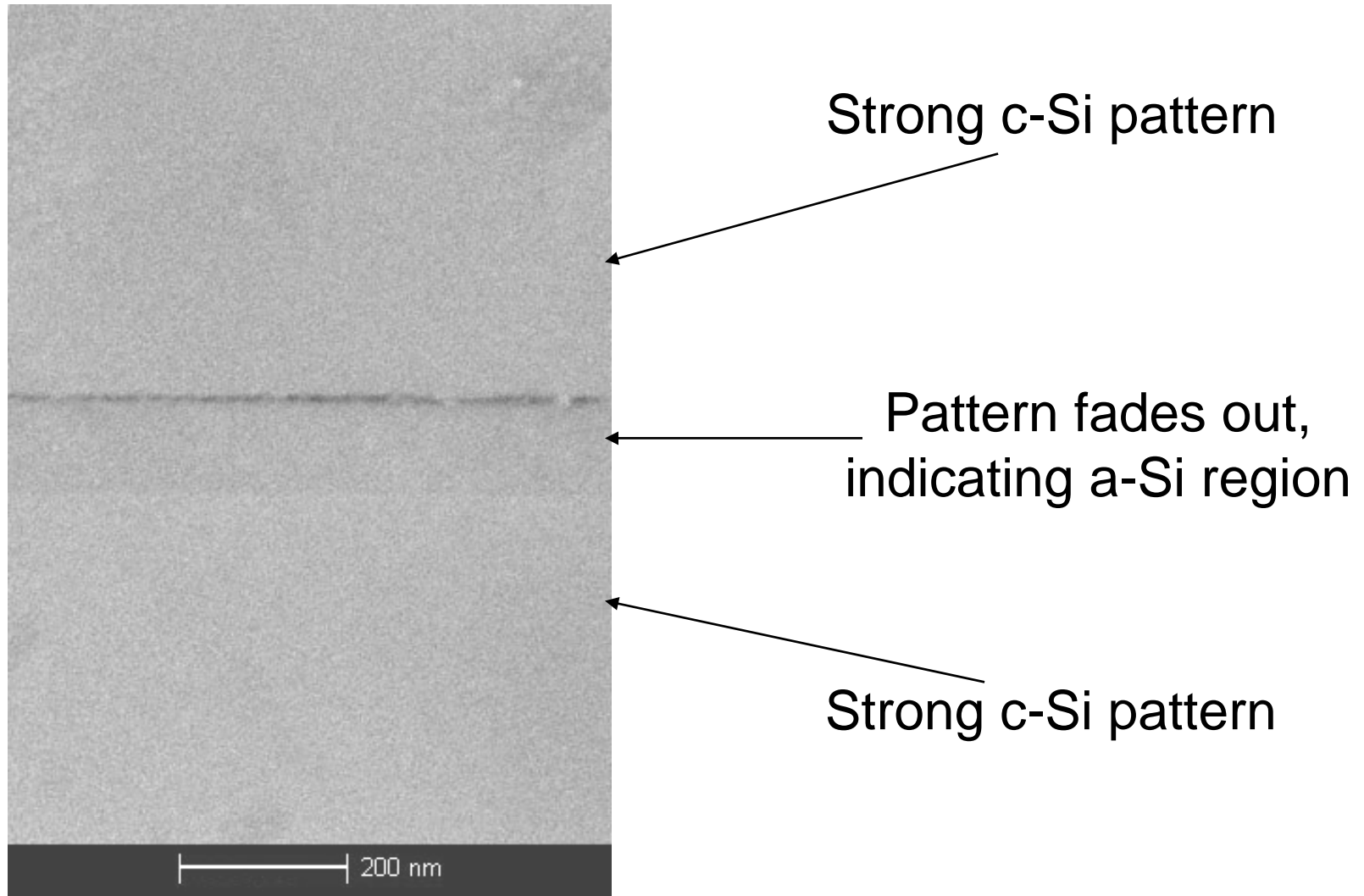
FPB, Notch on Film Side,
depth profile away from notch



SEM Characterization



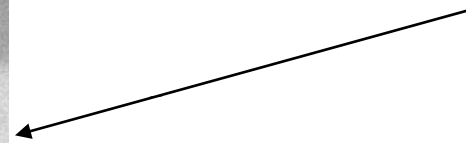
Electron Backscatter Diffraction



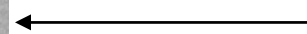
Electron Backscatter Diffraction



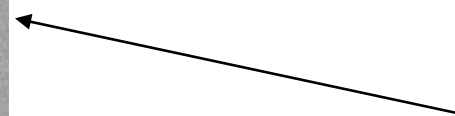
Strong (unsolved) pattern,
should be Al



Strong c-Si pattern
retained



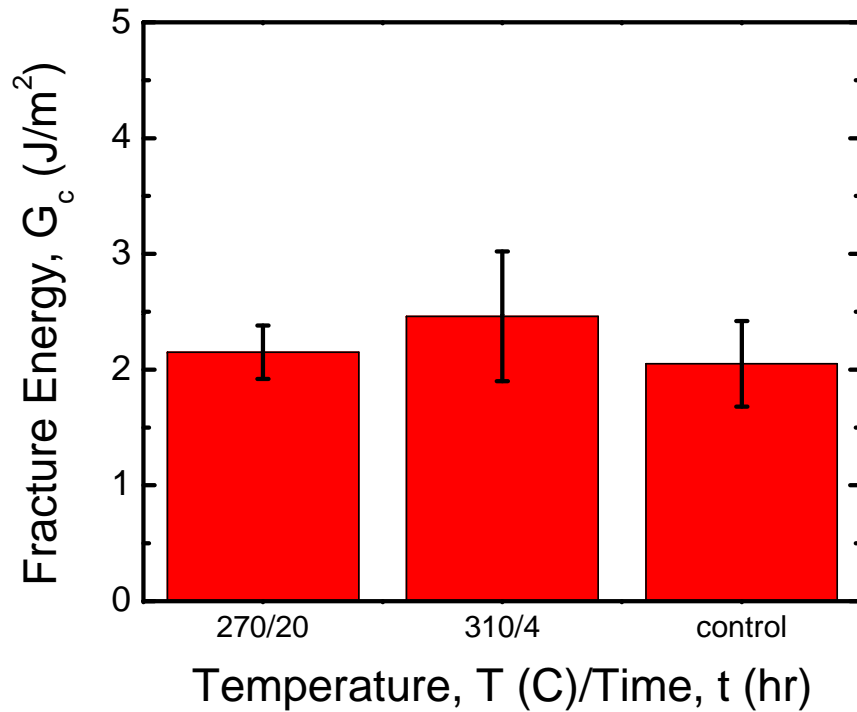
Strong c-Si pattern



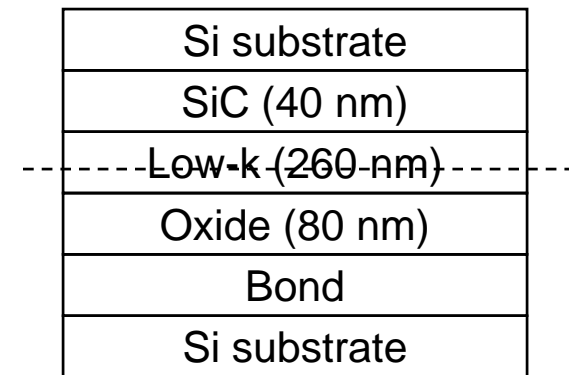
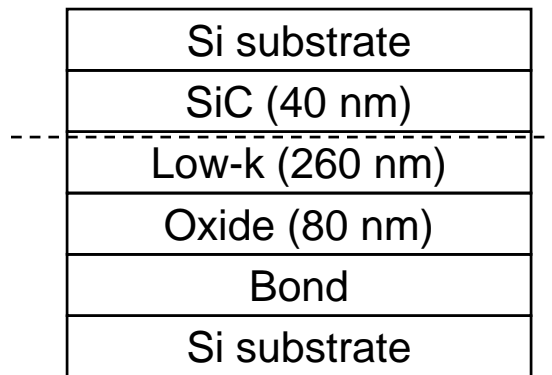
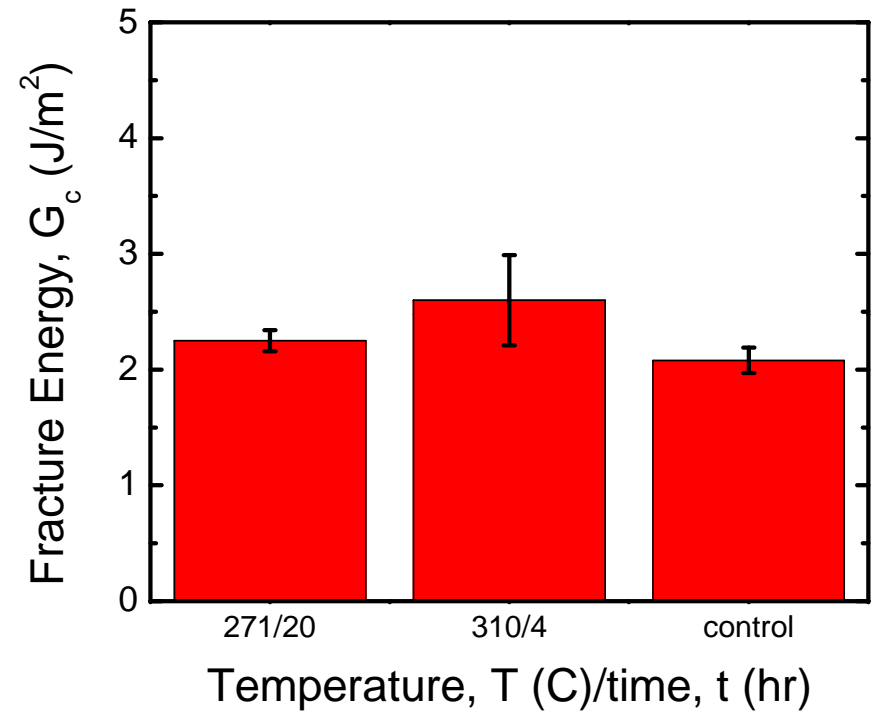
200 nm

Other Fracture Geometries

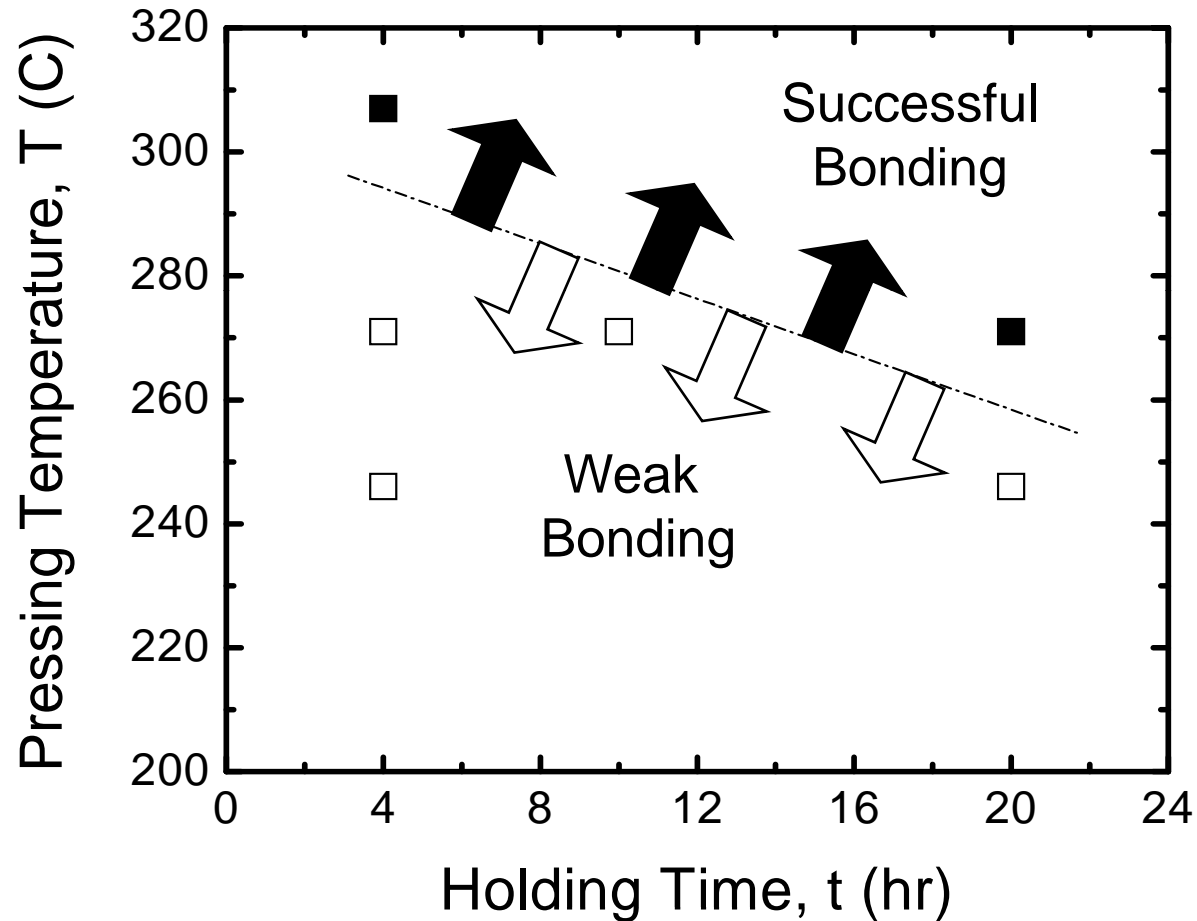
FPB, Notch on Blank Side



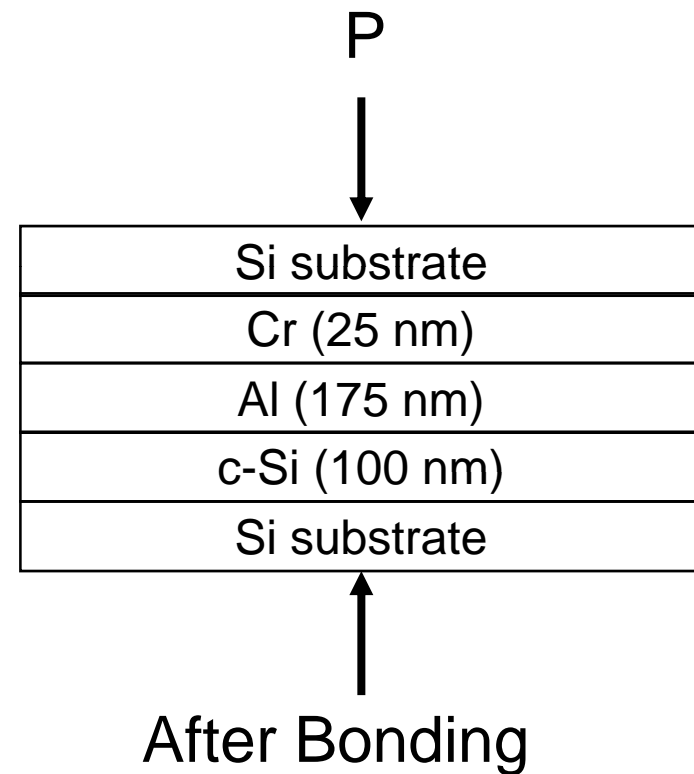
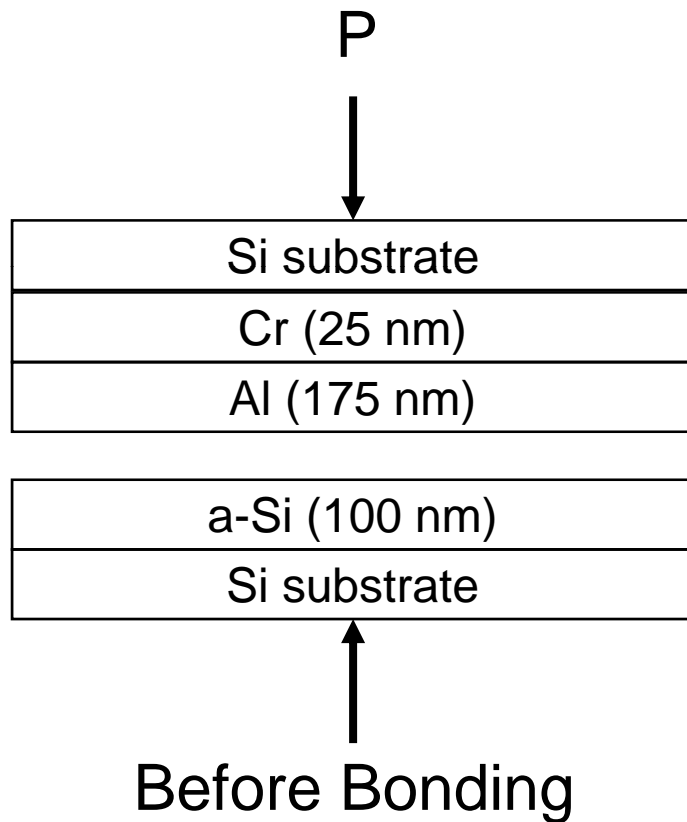
Double Cantilever Beam



Time/Temperature Dependence

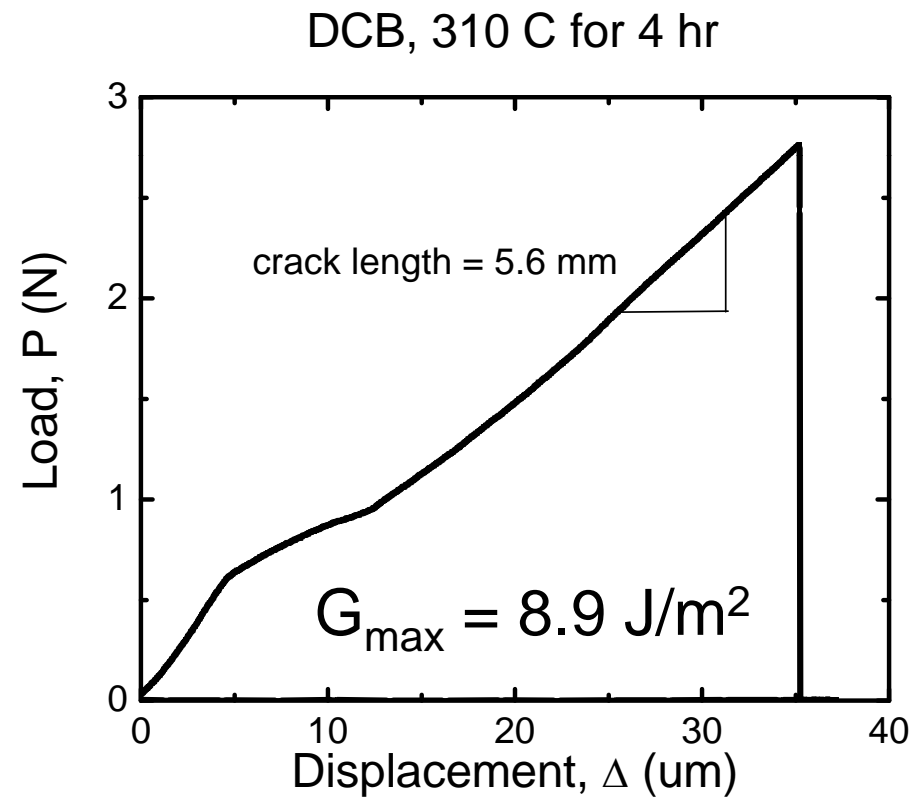
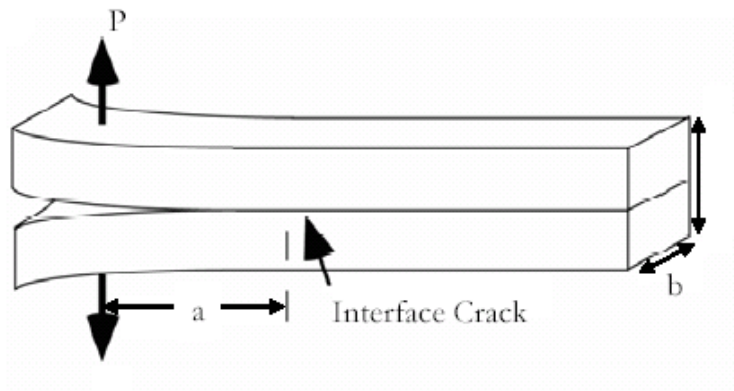


Film Stacks, no low-k



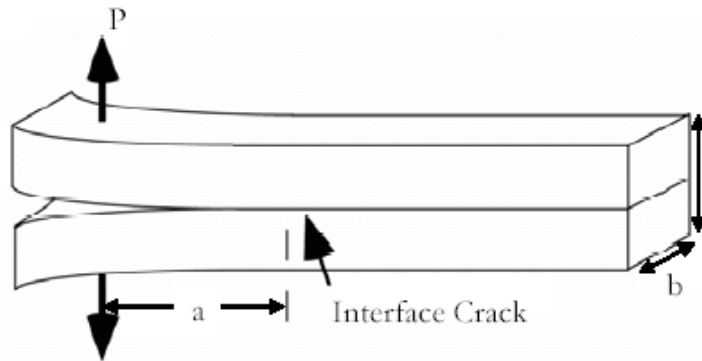
Bond Strength Fracture Tests

Strong bond makes measuring fracture energies difficult

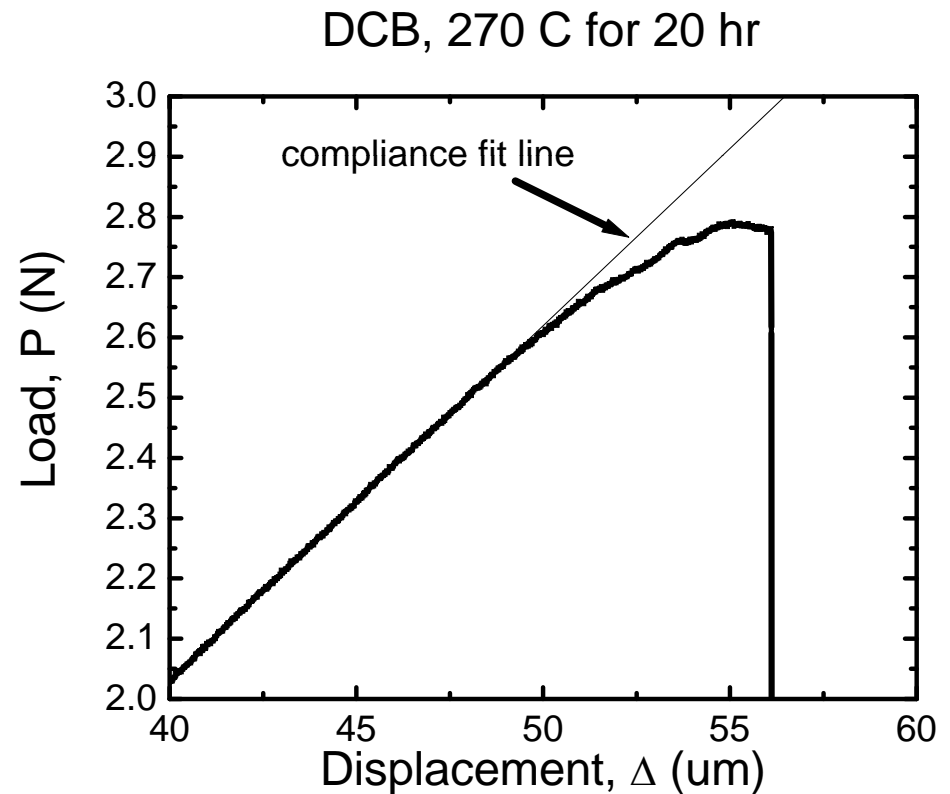


Bond Strength Fracture Tests

Strong bond makes measuring fracture energies difficult



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



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