Department of Mechanical and Industrial Engineering

DESIGN OF A FATIGUE MACHINE FOR THIN MEMBRANES

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FRACTURE CONTROL PROGRAM

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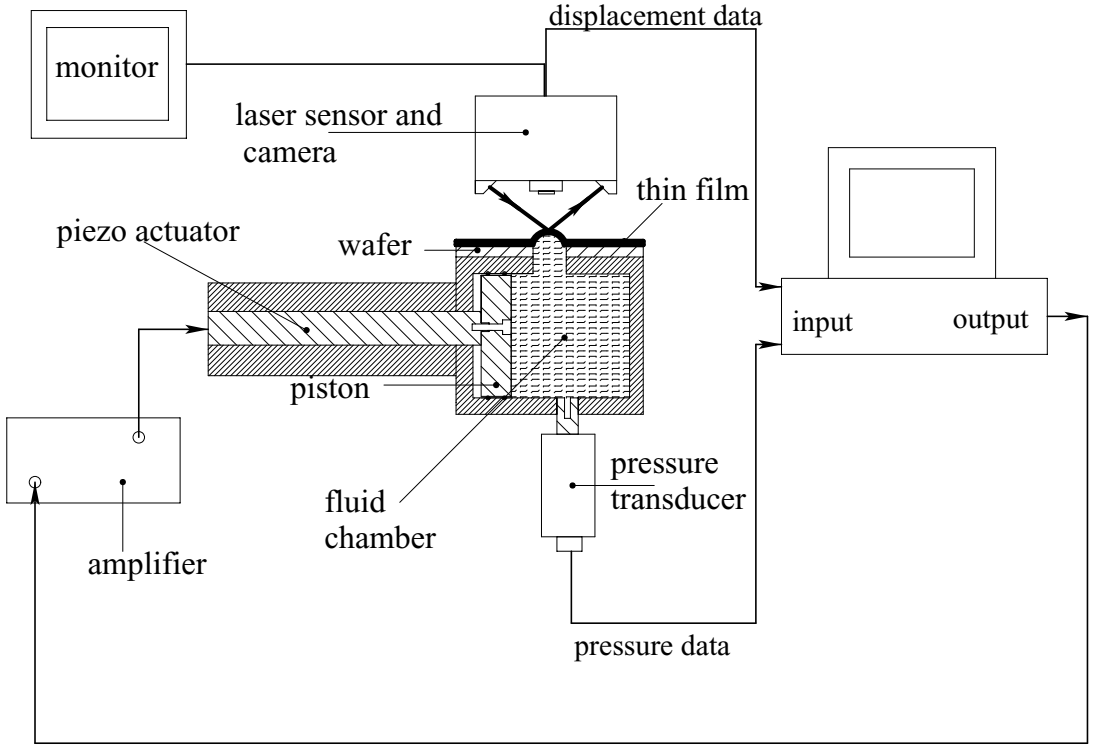
University of Illinois at Urbana-Champaign

BIAXIAL TESTING

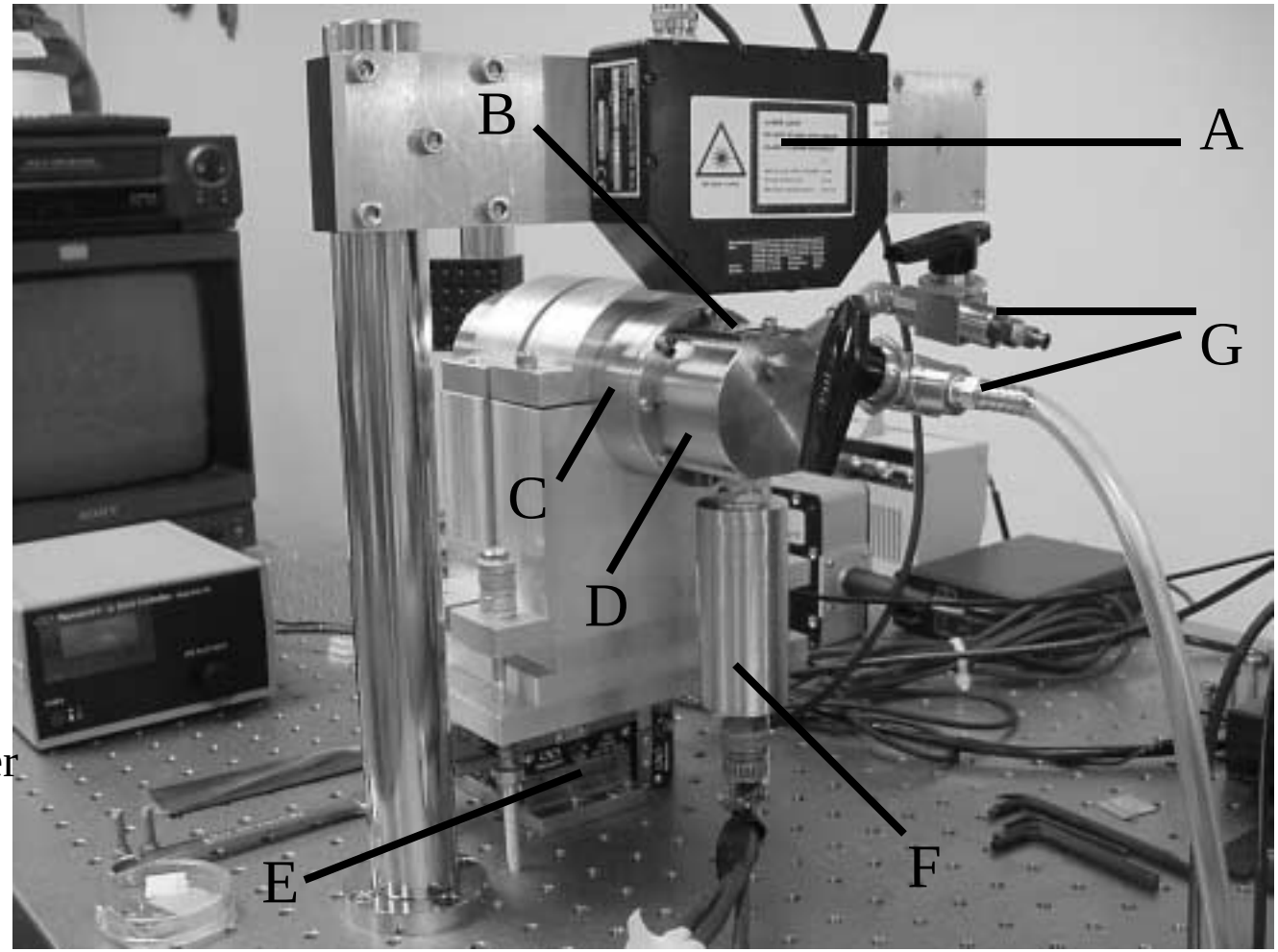
- NEW TESTING APPARATUS
  - MONOTONIC and
  - FATIGUE TESTING OF THIN FILMS



Feedback control drives piezo.

TESTING APPARATUS

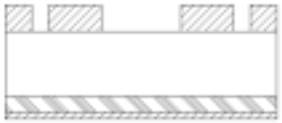
A:
Laser Sensor
B:
Specimen
C:
Piezo Actuator
D:
Fluid Chamber
E:
Multi-axis Stage
F:
Pressure Transducer



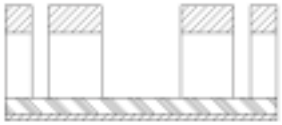
SPECIMEN FABRICATION

1. spin-coat and thermally imidize polyamic acid film
2. spin-coat protective photoresist thin film

3. spin-coat and pattern thick photoresist film



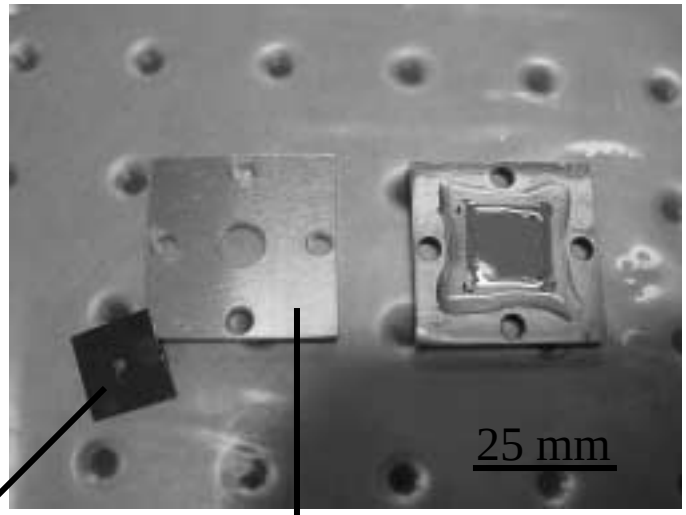
4. *ICP-DRIE*, anisotropic removal of bulk silicon



5. removal of photoresist in acetone bath
6. separate die, isopropanol rinse
7. vacuum dehydration bake

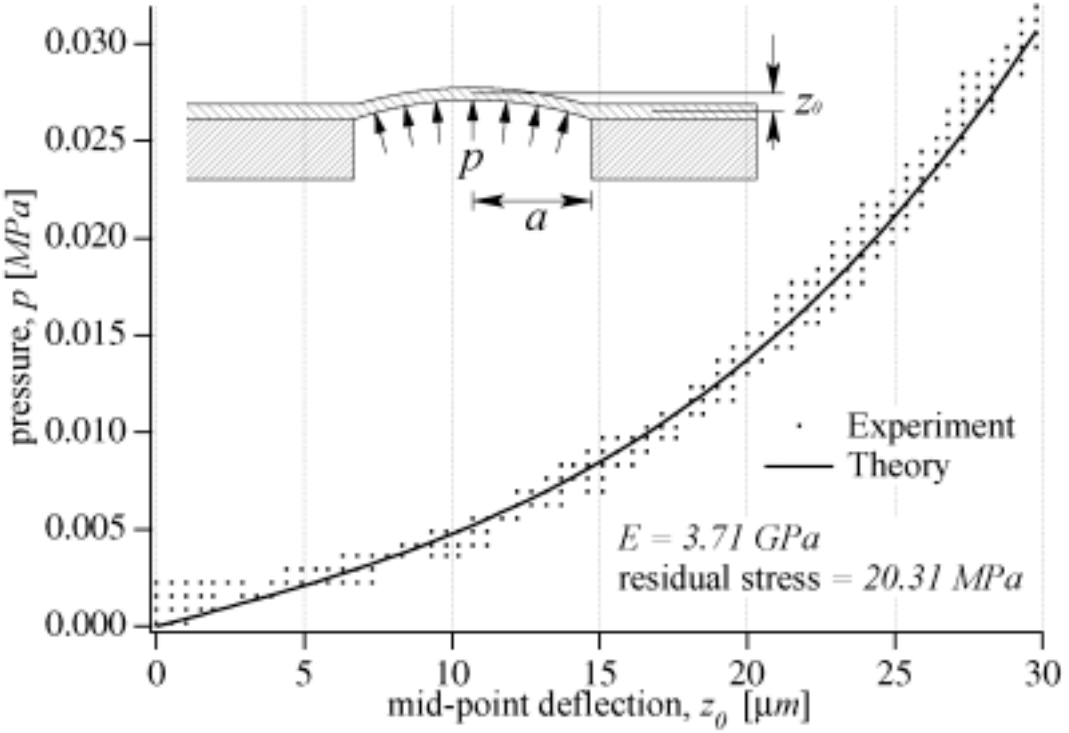
8. optional deposition of *Al* film

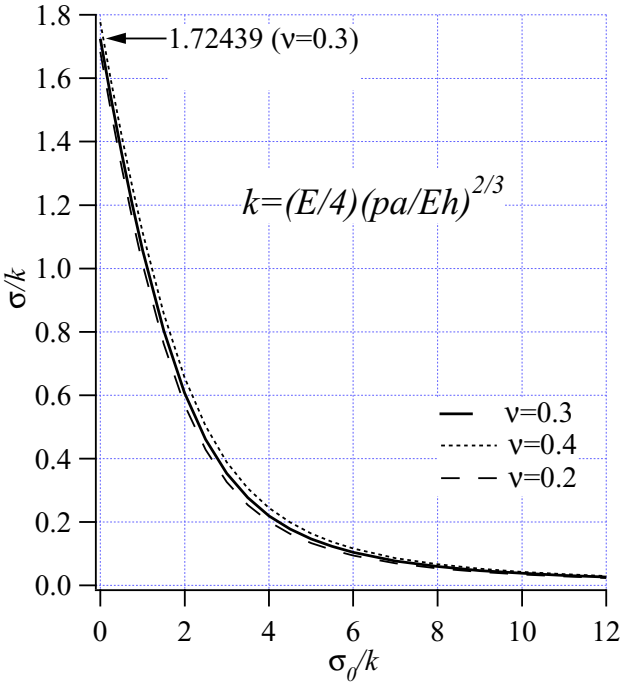
top view of finished specimen, no *Al* layer



MONOTONIC RESPONSE

4.6 μm-thick polyimide film





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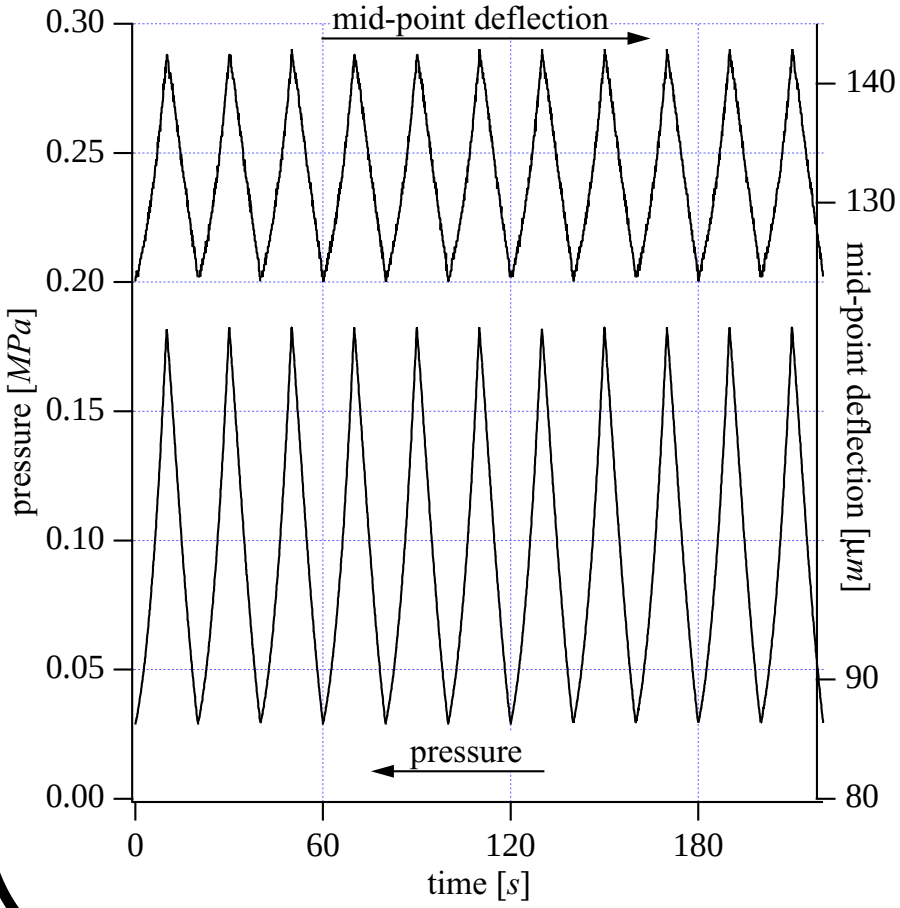
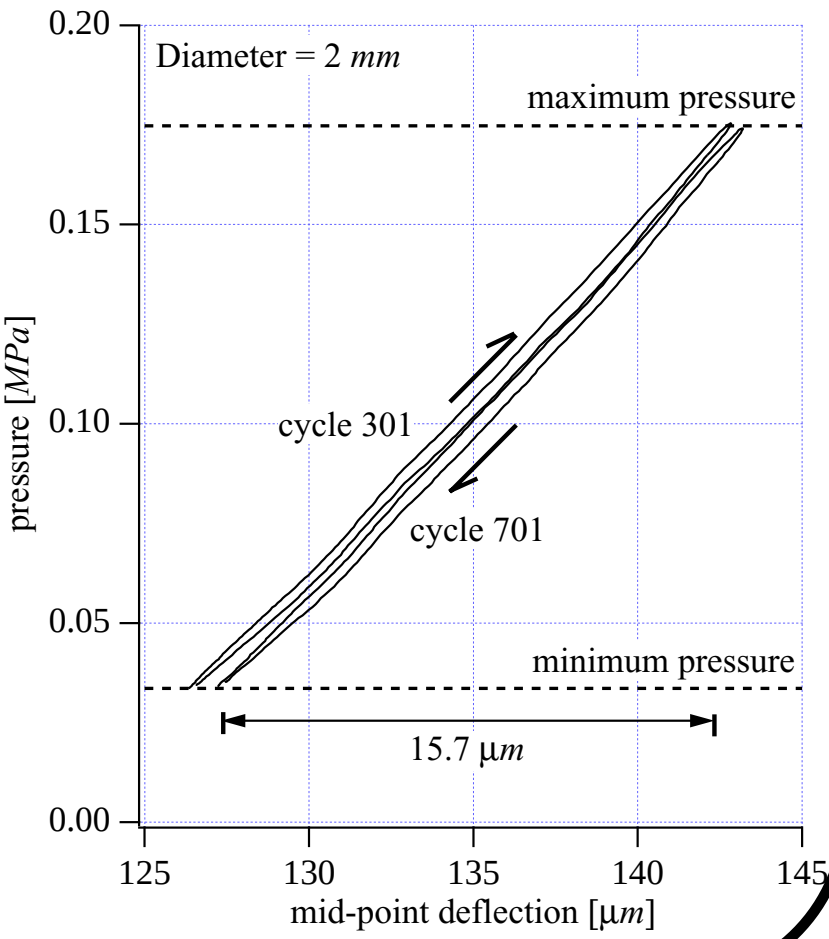
FATIGUE RESPONSE

4.6 μm-thick polyimide film





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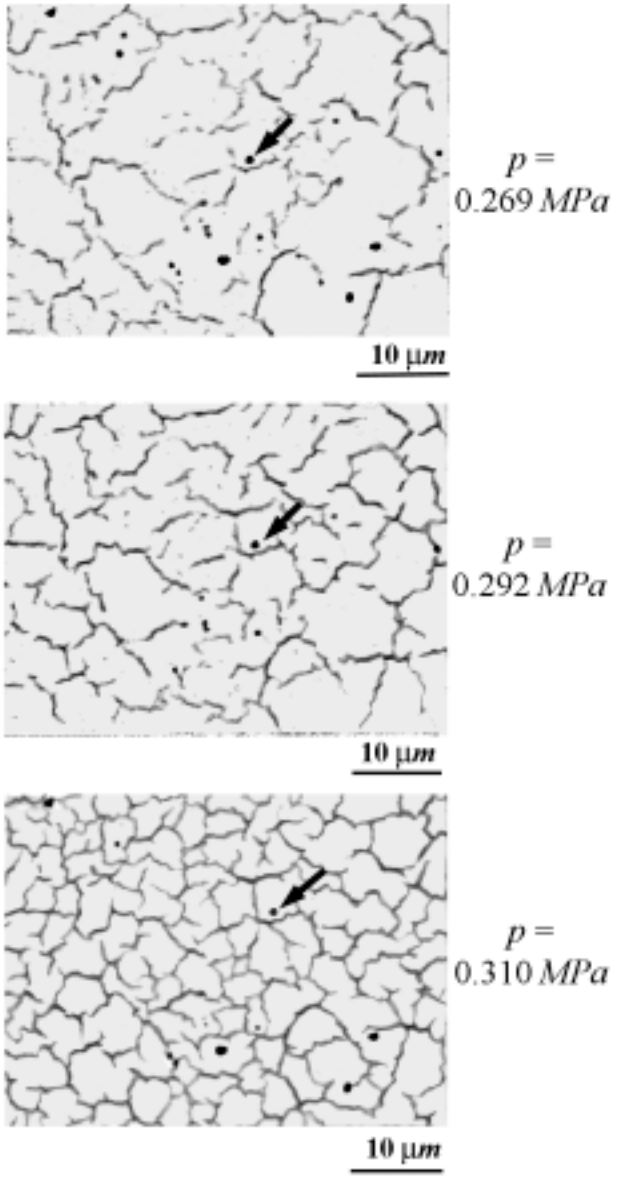
FRACTURE OF *150 nm*-THICK *Al* FILM ON *4.6 μm*-THICK POLYIMIDE SUBSTRATE

Vibration isolation and remote focusing make *in-situ* microscopy possible.

"Mud cracking" commonly observed in ceramic coatings, drying coffee-water mixtures, starch-water mixtures,volcanic rocks, desiccating mud and clays.



DETERMINATION OF THE CRITICAL STRESS INTENSITY FACTOR FOR *150 nm* -THICK *Al*

1. $$G = \frac{1}{2}\frac{\left(1-\nu_f^2\right)h\sigma^2}{E_f}\pi g(\alpha,\beta)$$

   Beuth, *Int. J. Solids Structures*, 1992

2. Steady-state channeling of isolated, straight cracks takes place at $p = 0.235\ MPa$.

$$\boxed{K_I^c = 1.670\,MPa\sqrt{m}}$$

CONCLUSION

- New apparatus to conduct fatigue testing on thin films.
- Elastic properties are extracted from monotonic tests.
- Critical stress intensity factors can be determined for thin films using *in-situ* microscopy.