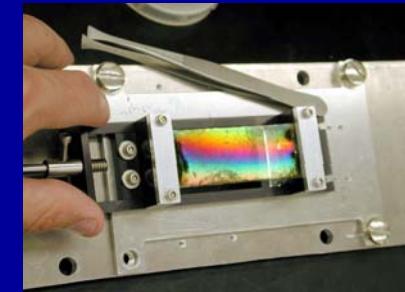
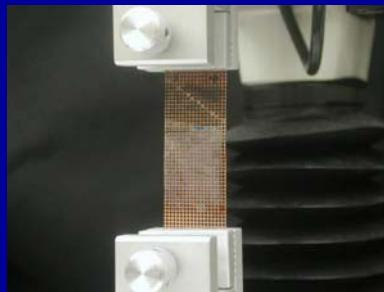
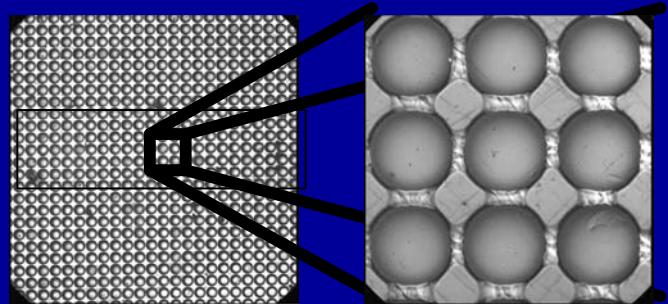




Adhesion and Mechanical Properties



**C. Stafford, C. Davis, K. Beers, C. Harrison,
R. Song, A. Forster, A. Chiche, M. Chiang,
A. Karim**

9.12.02

Adhesion & Mechanical Properties



- Combinatorial Adhesion
 - (1) Multilens Combinatorial Adhesion Test (MCAT)

| | |
|-------------|------------|
| A. Crosby | C. Davis |
| C. Stafford | A. Forster |

2+ yrs
 - (2) Combinatorial Peel Test

| | |
|---------|-----------|
| R. Song | A. Crosby |
|---------|-----------|

1 yrs
- Mechanical Properties
 - (3) High-Throughput Modulus

| | |
|-------------|-------------|
| C. Harrison | C. Stafford |
|-------------|-------------|

6 mo.
 - (4) Combinatorial Fracture

| | |
|----------|-----------|
| K. Beers | A. Crosby |
|----------|-----------|

6 mo.

Adhesion



Need:

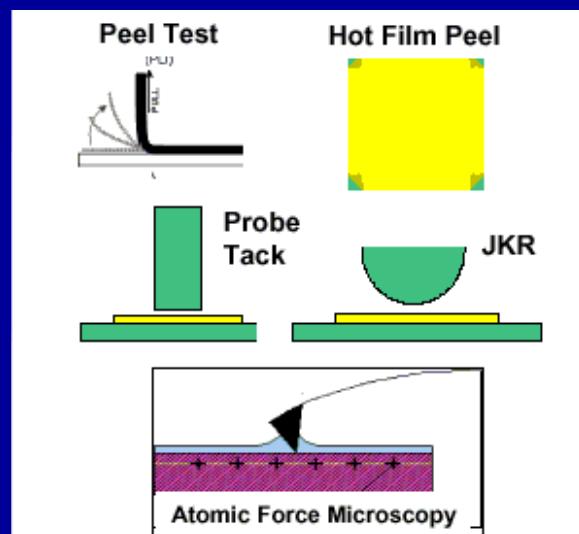
- ☛ Develop multivariable methodologies to quantitatively probe the adhesive strength at polymeric interfaces.

- ☛ Office Supplies
 - ☛ 3M Scotch Tape, Post-it Notes, PSA
- ☛ Electronic Packaging
- ☛ Paints and Coatings
- ☛ Biomedical and Biological Adhesion

- ☛ How does one measure adhesion / tack?

- ☛ What forces come into play?

- ☛ van der Waals interactions
- ☛ covalent bonds
- ☛ entanglements
- ☛ electrostatic
- ☛ dissipative processes

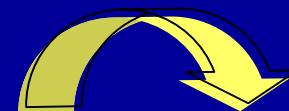
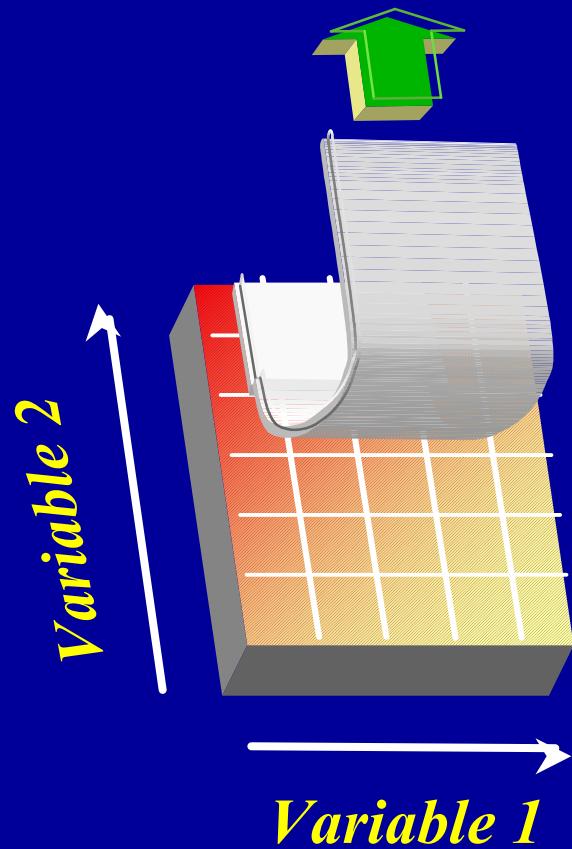


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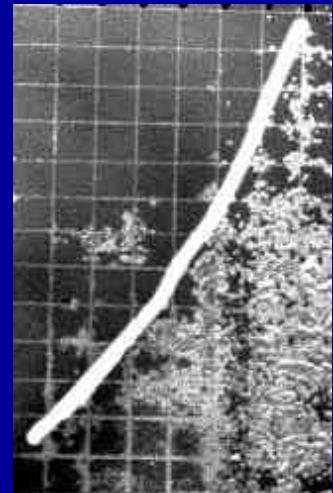
Adhesion/Debonding



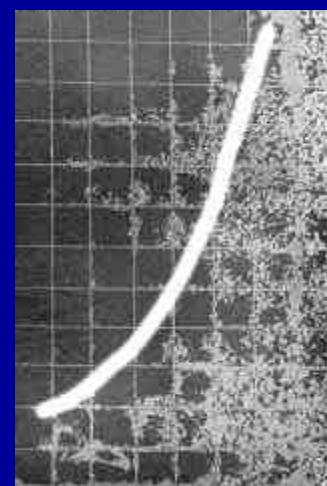
180° Peel Test on Combinatorial Libraries



thermal



peel

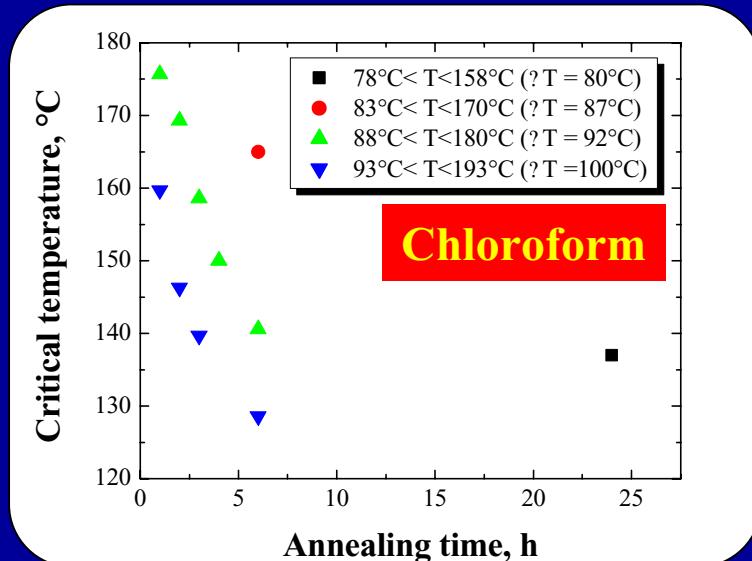
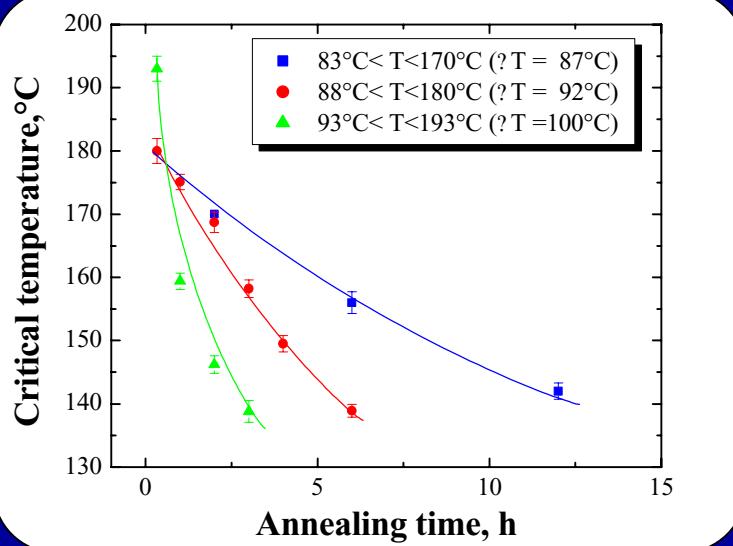


R. Song

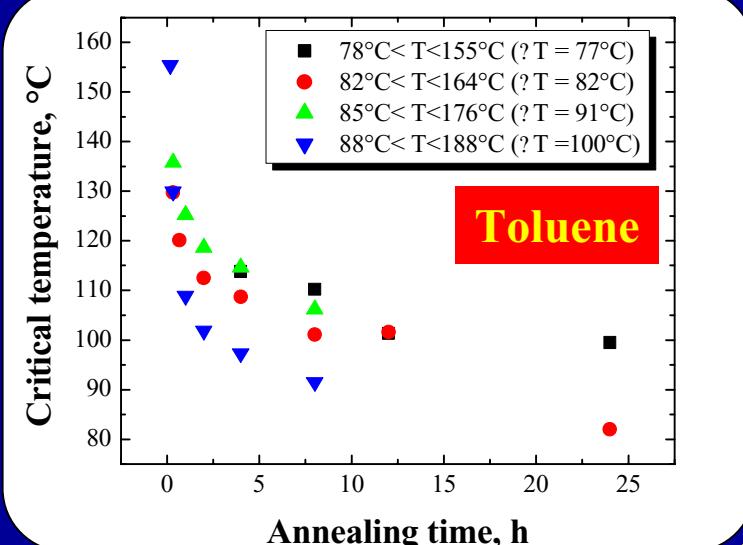
9.12.02



Adhesion/Debonding



☞ We can evaluate processing conditions on the adhesive failure of polymer films.



Adhesion/Debonding



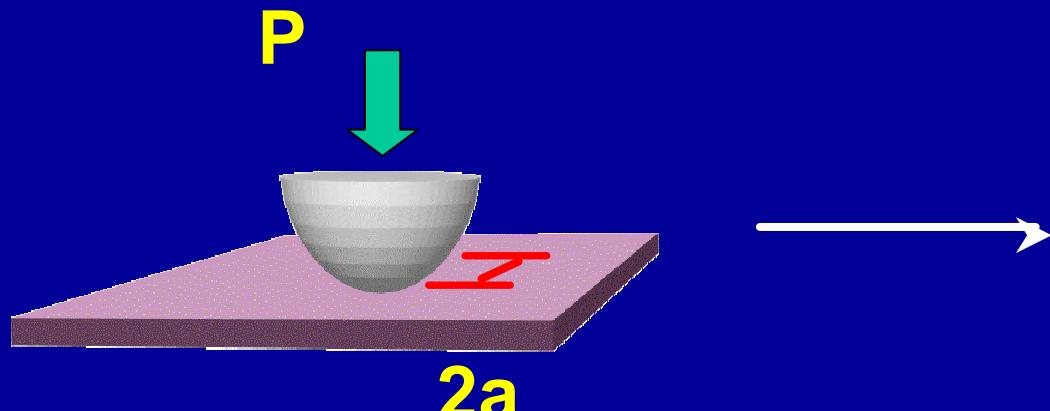
Future Directions FY03

- ✉ Continue studying affects of processing history:
 - ✉ annealing temperature
 - ✉ annealing time
 - ✉ residual solvent effects
- ✉ Move into metal/polymer adhesion.
- ✉ Examine typical commercial photoresist.
- ✉ Explore model PSA system in conjunction w/ Formulations Group.
- ✉ Further develop simulations effort to construct predictive models of adhesive failure.

Multilens Contact Adhesion Test

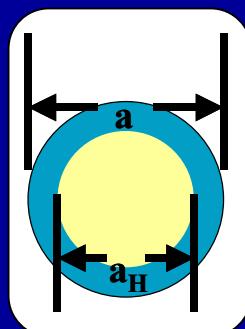


Classical JKR Approach

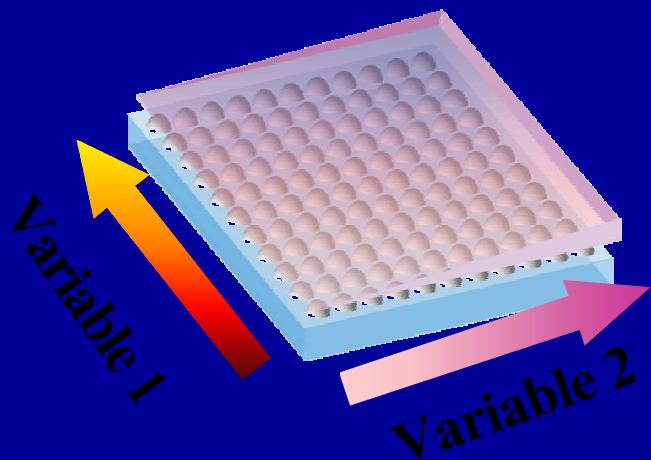


$$G \approx \frac{3(P' - P)^2}{32\pi E a^3}$$

Johnson, K.; Kendall, K.; Roberts, A.
Proc. R. Soc. Lond. A. 1971, 324, 301.



Combinatorial Approach

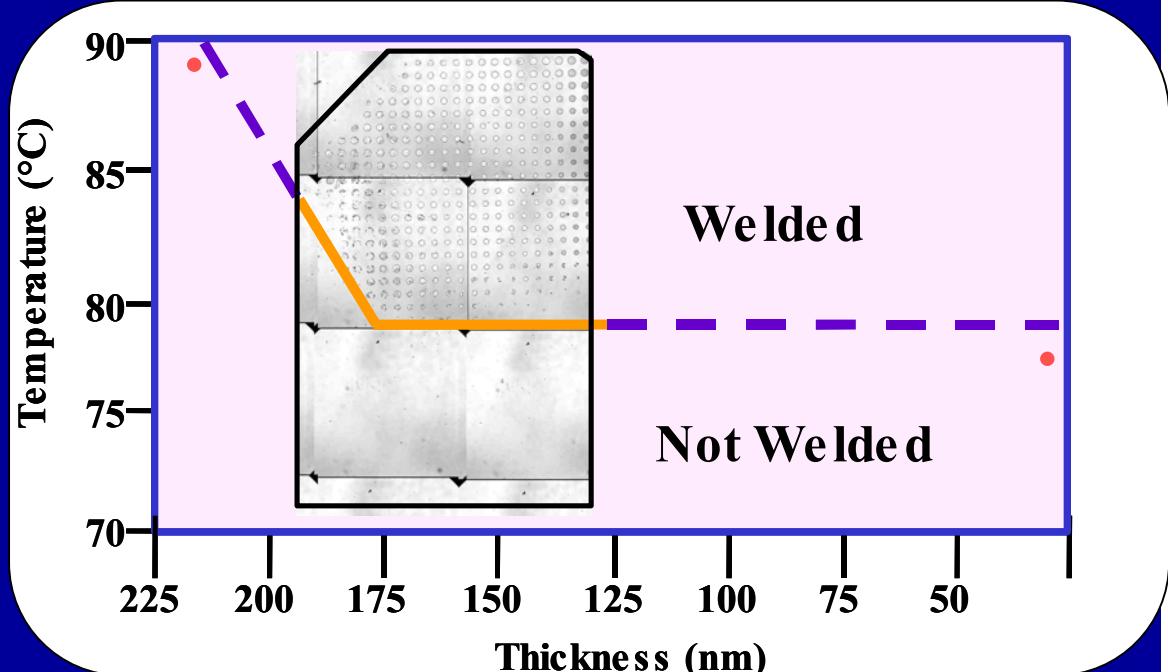
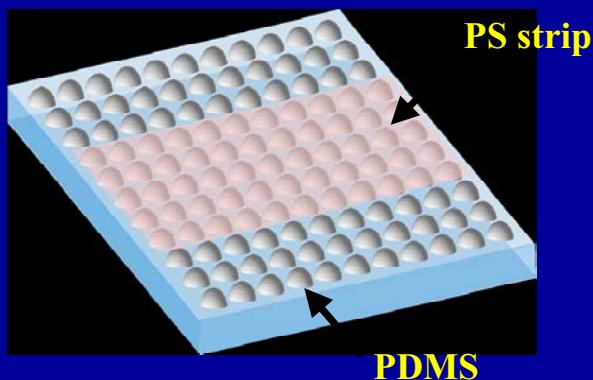


$$G \approx \frac{2E^{1/2} \gamma \delta^2}{3\pi a}$$

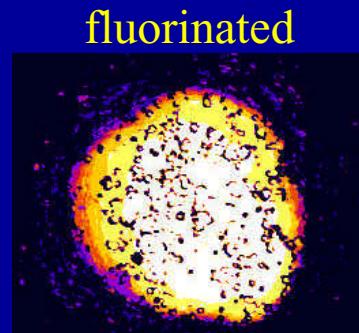
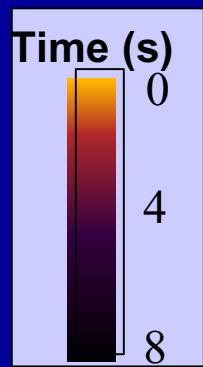
Crosby, A., et al., *J. Polym. Sci. Part B: Polymer Physics*, to be submitted.



Validation Experiments:

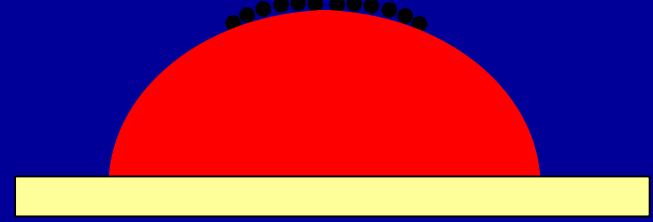


Dynamics of Adhesion:

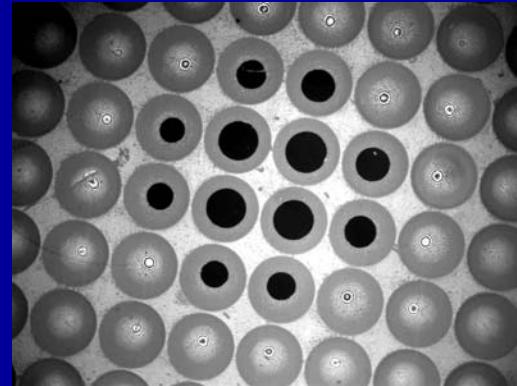
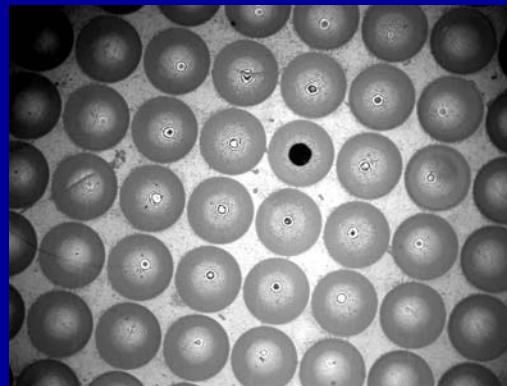
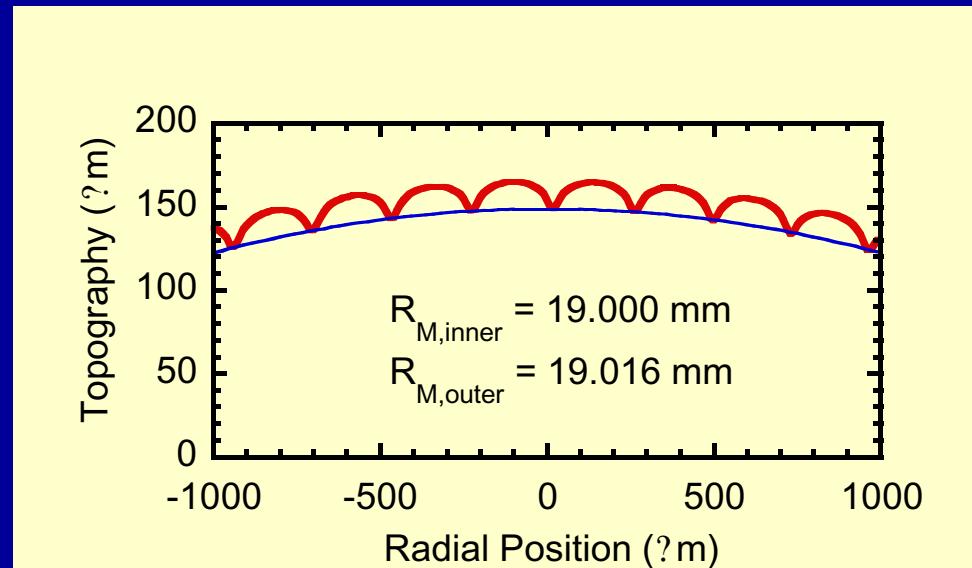


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MCAT



Stretched ?Lens on PDMS Macrolens

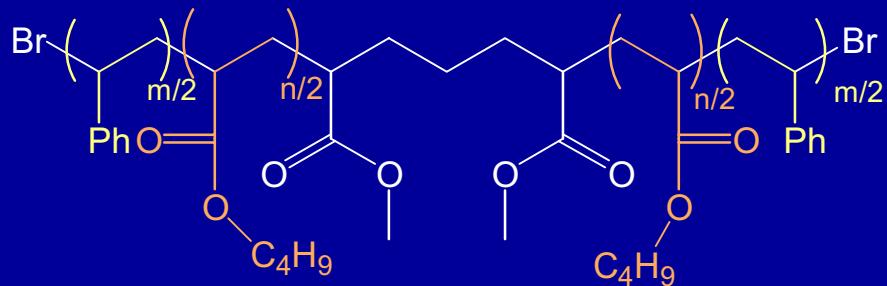


? $h \sim 1 \text{ ?m}$
explore strain gradients



Future Directions FY03

- ✉ Demonstrate MCAT on some practical systems.
- ✉ Hold NCMC Meeting on Adhesion & Mechanical Properties.
- ✉ Explore model PSA system in conjunction w/ Formulations Group.
- ✉ Continue to hone MCAT (i.e. temperature gradient, tip/tilt).
- ✉ Explore crosslink density vs. surface energy via adhesion.
- ✉ Study polymer/metal adhesion.
- ✉ Develop test methodology(s) for weak force adhesion.
- ✉ Develop methodology for adhesion on rough surfaces.



p(S-b-nBA-b-S):
 $M_n = 105,000$
 $M_w/M_n = 1.08$

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Mechanical Properties

Need:

❖ Develop simple yet reliable, high-throughput techniques by which material properties can be measured.

❖ Modulus

❖ Strength

❖ Viscoelasticity

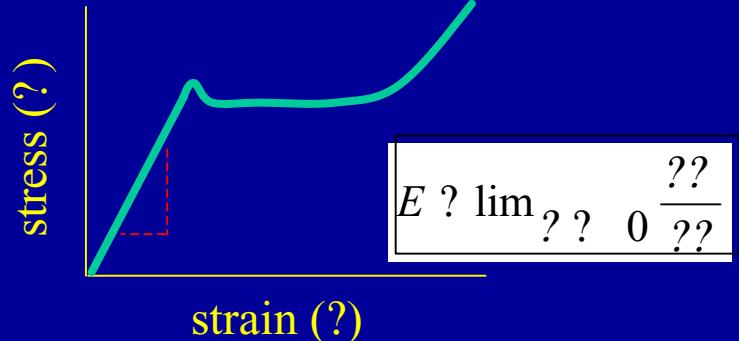
❖ Creep

❖ Toughness

❖ Crazing / Fracture

etc.

Who Cares?



$$E ? \frac{?}{?}$$

$$G ? \frac{E}{2(1+?)}$$

$$K ? \frac{E}{3(1+2?)}$$

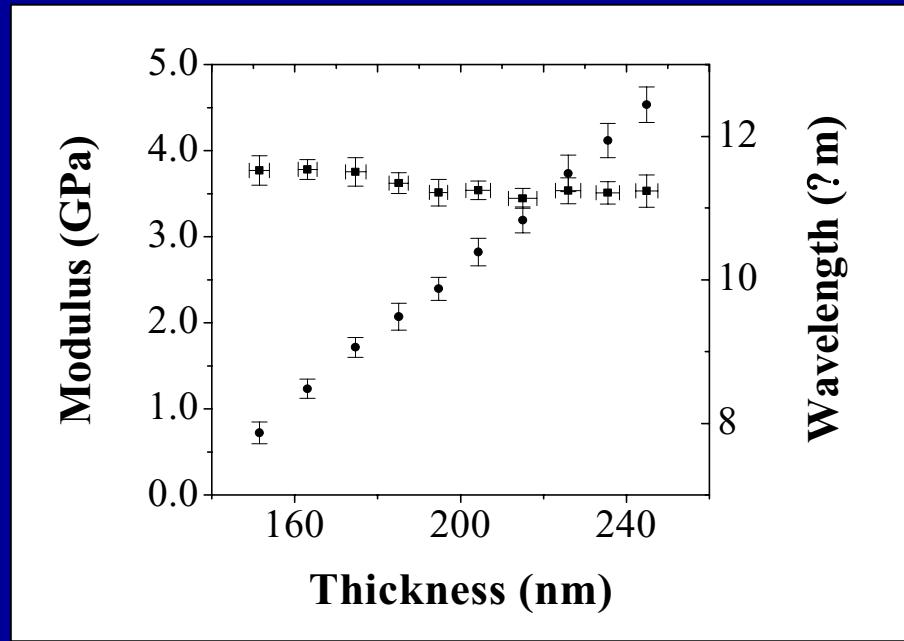
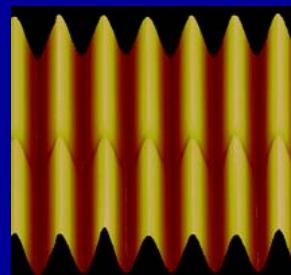
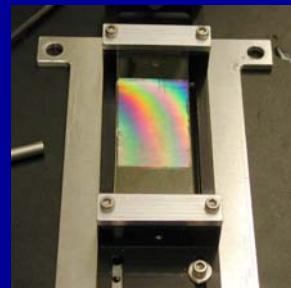
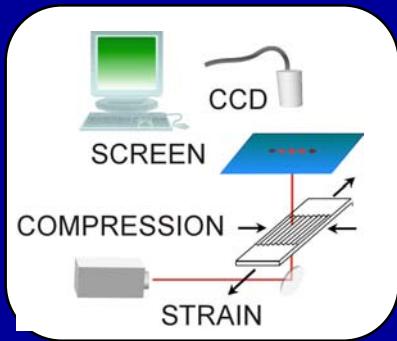
$$\text{Flexural Rigidity} ? Et^3$$

$$?_t ? \frac{E}{10}$$

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Modulus of Thin Films



$$E_p \approx 4E_m(1 - \nu_p^2)\left(\frac{d}{2h}\right)^{1/3}$$

E_p – modulus of the upper film d – buckling wavelength

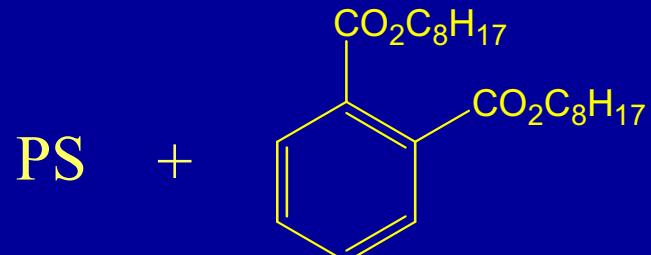
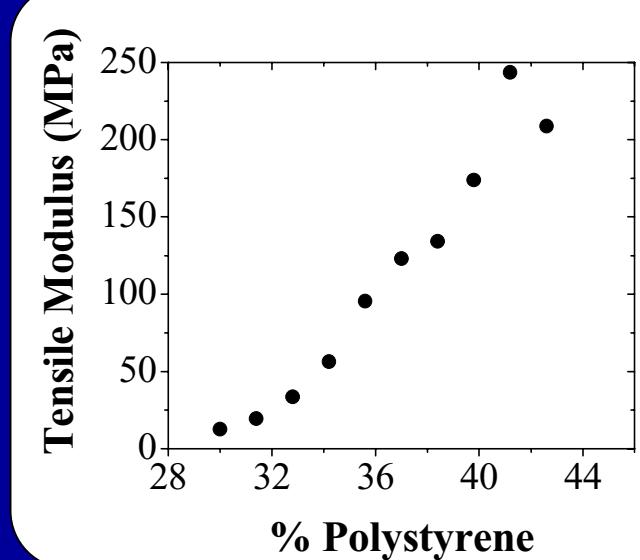
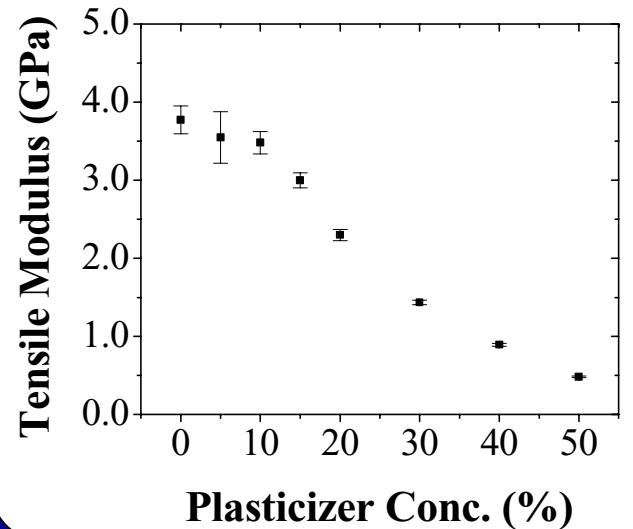
E_m – modulus of PDMS sheet h – thickness of upper film

ν_p – Poisson's ratio of the upper film

Groenewold, J., *Physica A* 2001, 298, 32.

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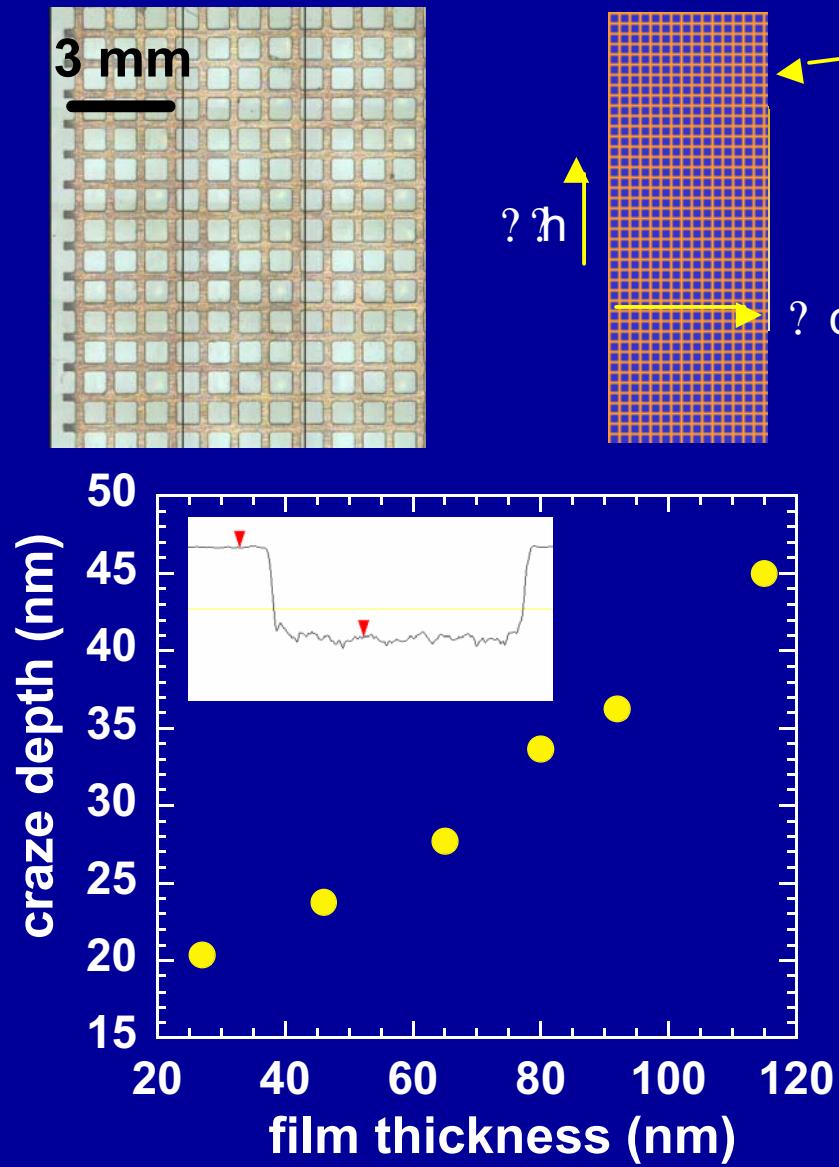
Modulus of Thin Films



PS-PI triblocks
(Vector 4215 & 4411)

PI – soft / rubbery
PS – glassy

Combinatorial Crazing/Fracture



9.12.02

Modulus/Crazing



Future Directions FY03

- ✉ Prove robustness of modulus measurement.
 - ✉ UV-crosslinked systems
 - ✉ nanocomposites/nanotubes
 - ✉ thermal annealing / processing history
- ✉ Explore amplitude of buckling instabilities.
- ✉ Correlate AFM data on crack formation w/ light scattering data.
- ✉ Draw on craze/fracture skill set to better understand crack formation.
- ✉ Explore composition gradients.
- ✉ Open doors to other uses for this phenomenon.



Mechanical Properties

Need:

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❖ Modulus
❖ Strength
❖ Viscoelasticity

❖ Creep
❖ Toughness
❖ Crazing / Fracture

etc.

Who Cares?

