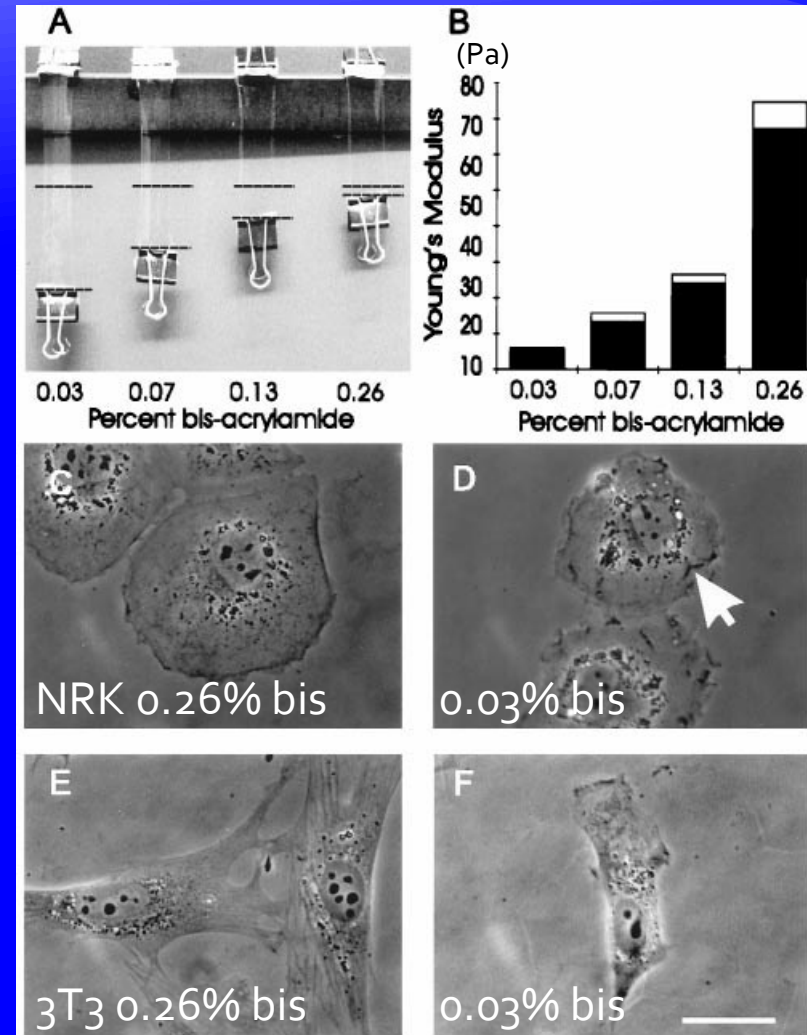Session 20

TRACTION FORCE CONTINUA

Polyacrylamide Gels

- Cells sense and respond to substrate elasticity

- Aim: vary substrate stiffness with constant chemical adhesiveness

  - Polyacrylamide gels with collagen coating

  - Bis-acrylamide cross-links gel and increases stiffness

Pelham RJ, Wang YL (1997) PNAS, 94:13661

Traction Force Microscopy
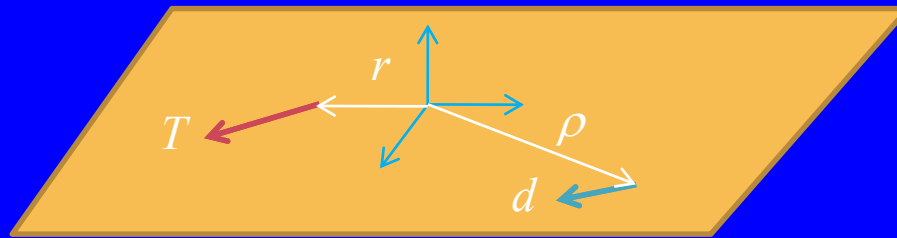
- Embed fluorescent microbeads into gel
- Observe bead positions under and around cell
- Remove cell and record cell-free positions
- Calculate the "most likely" traction forces
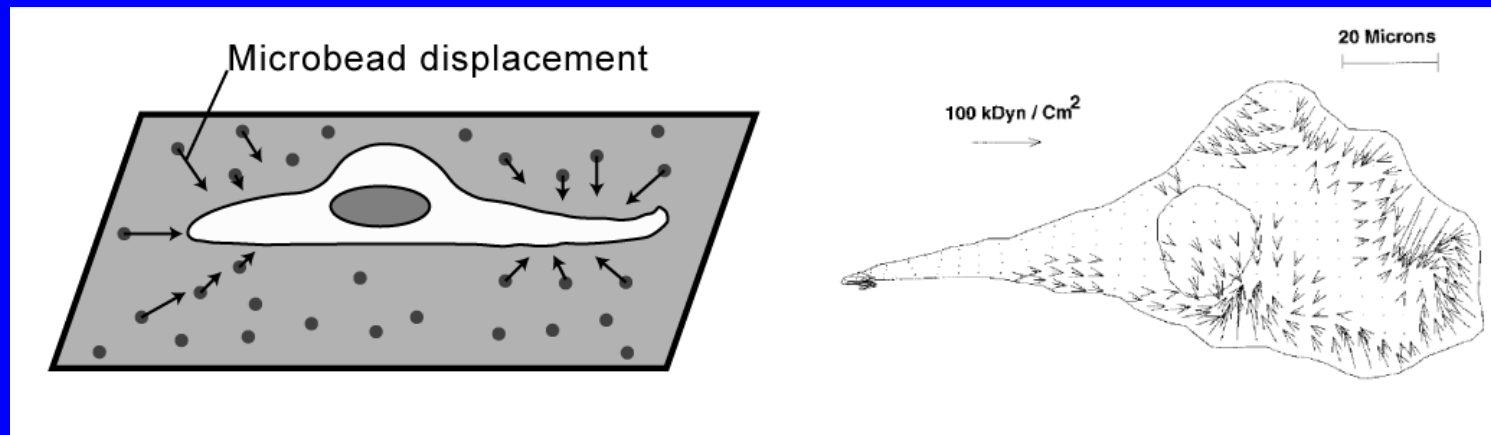
Bousinesq (Cerruti) Problem

- Tangential force acting on an elastic half-space
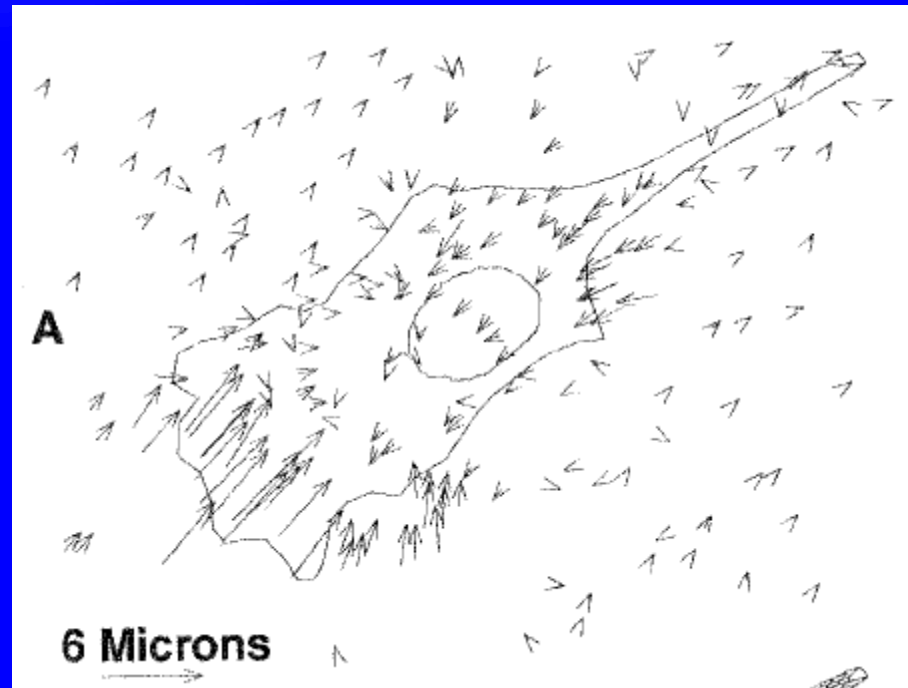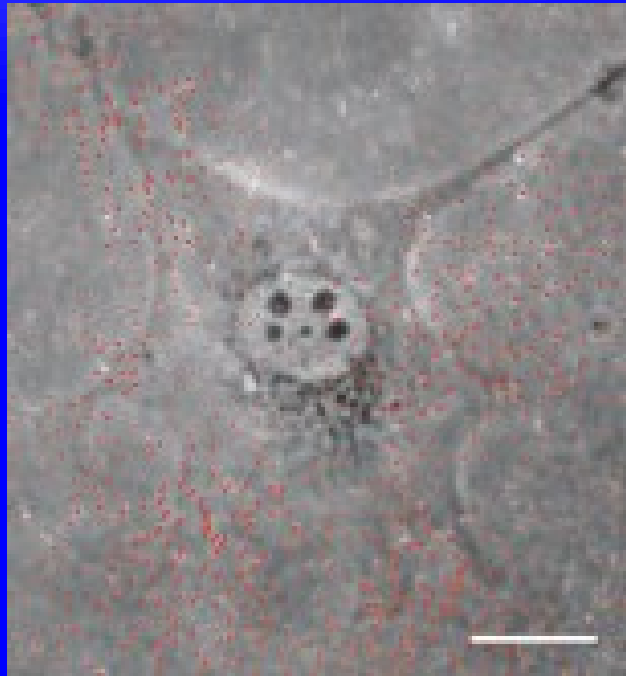- Displacement of particle p is

$$d_{pi} = \iint g_{ij} (\quad)$$

- Green's tensor g_{ij} gives displacement in i-direction at location ρ due to concentrated force T at location r acting in j-direction
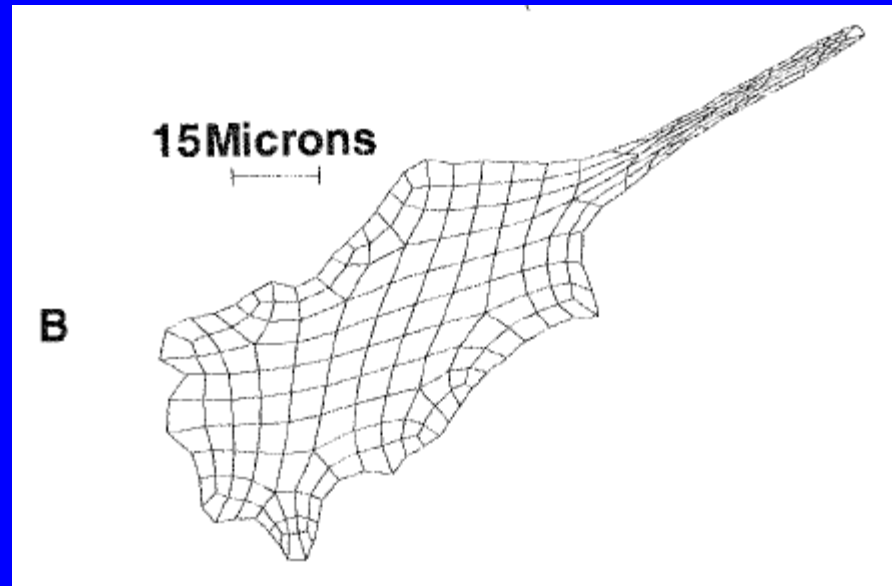
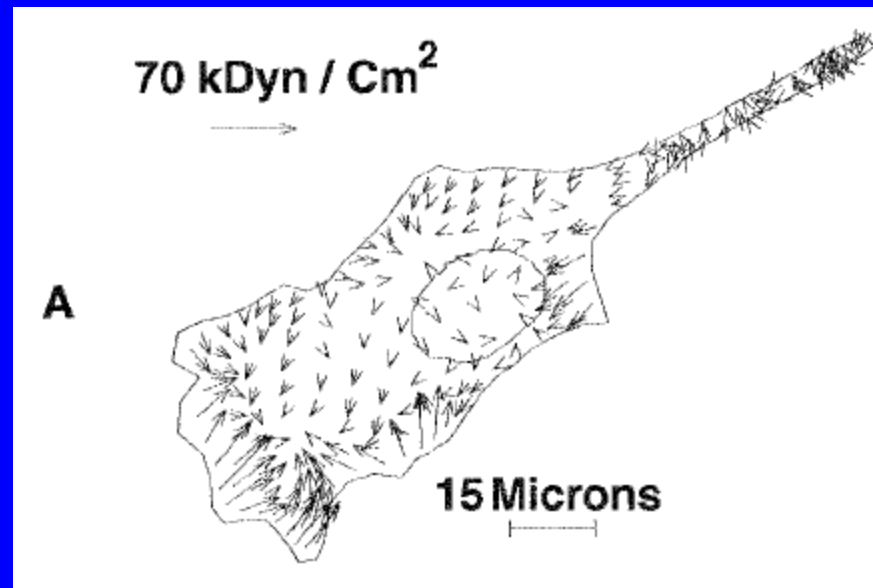# Optical Imaging of Displacements

- Arrows indicate displacement of beads

Finite Element Meshing

◆ Quadrilateral mesh

 ◆ Define region where traction can exist

15Microns

B

Predicted Traction Field

◆ Invert displacement equation to solve for traction field

Expected Displacement Field

- Likelihood of traction field solution
  - Minimized Chi-squared comparison
    - Lowest difference between observed and expected displacements
 - Minimized complexity
    - Lowest average traction field density

Observed

A

6 Microns

Expected

B

6 Microns
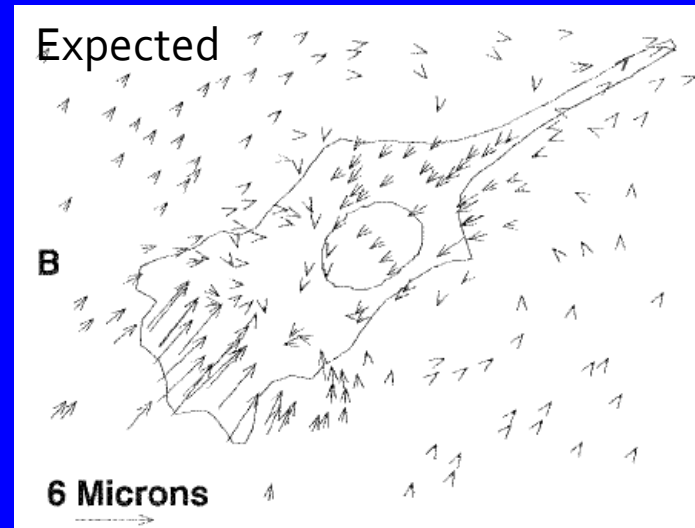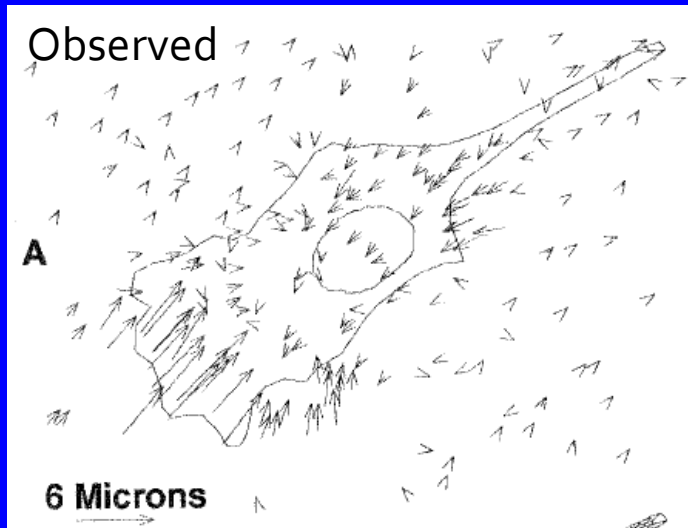
Improvements
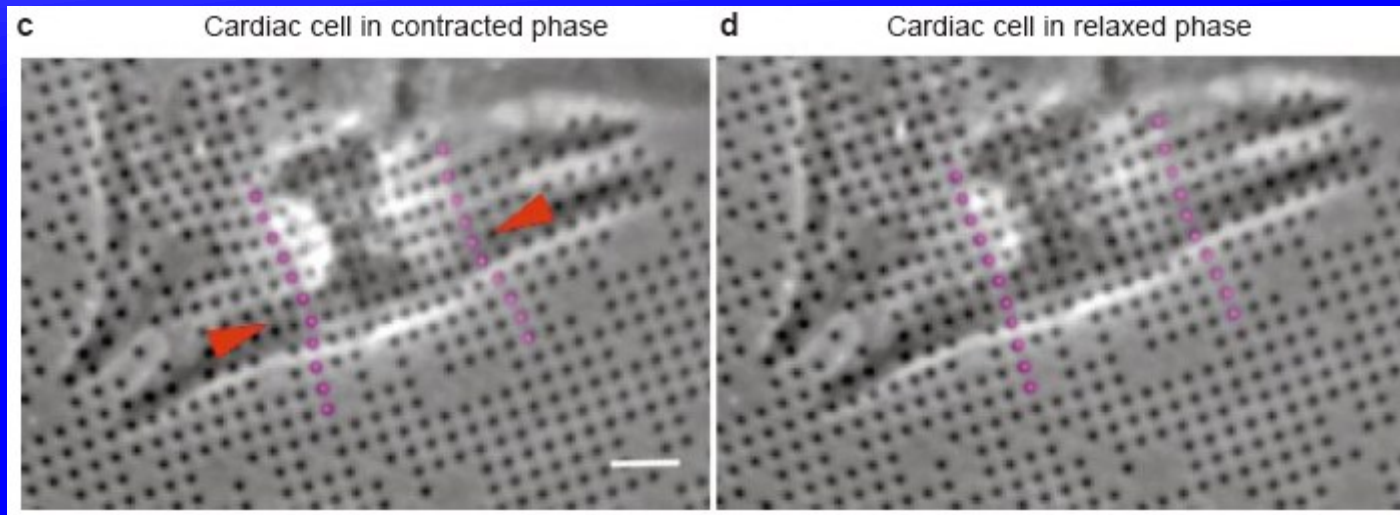
- Changes in ligand coating
- Finite thickness consideration
- New computation approaches
  - Fourier space analysis (Butler & Fredberg)
  - Exact solution to elastic half-space (Aliseda & Lasheras)

Micropatterned Substrates

- Photolithography approach
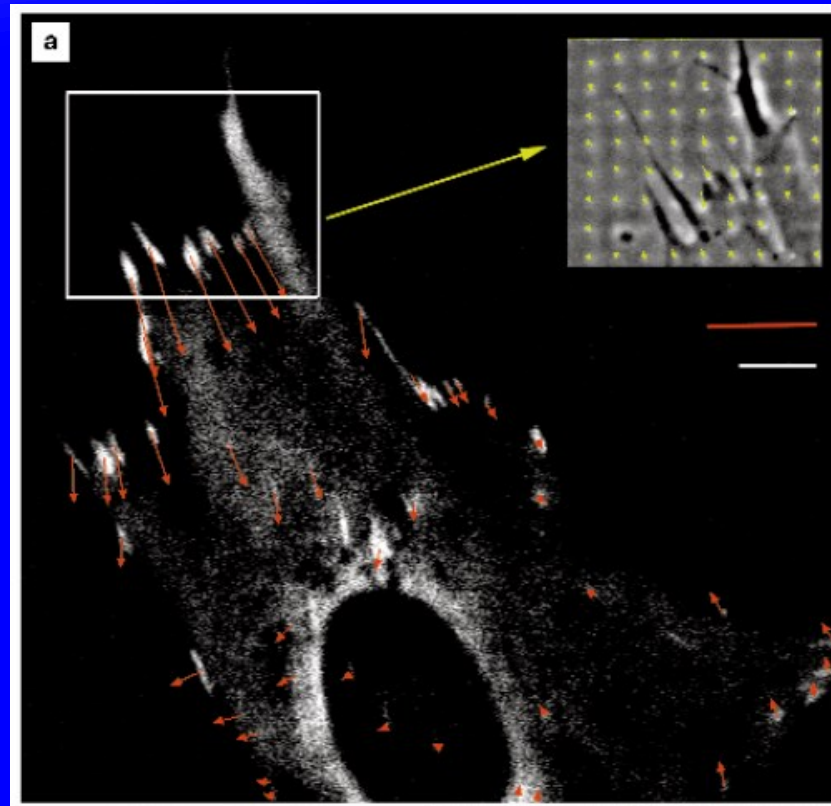 - Marker pits
  - Fluorescent dots
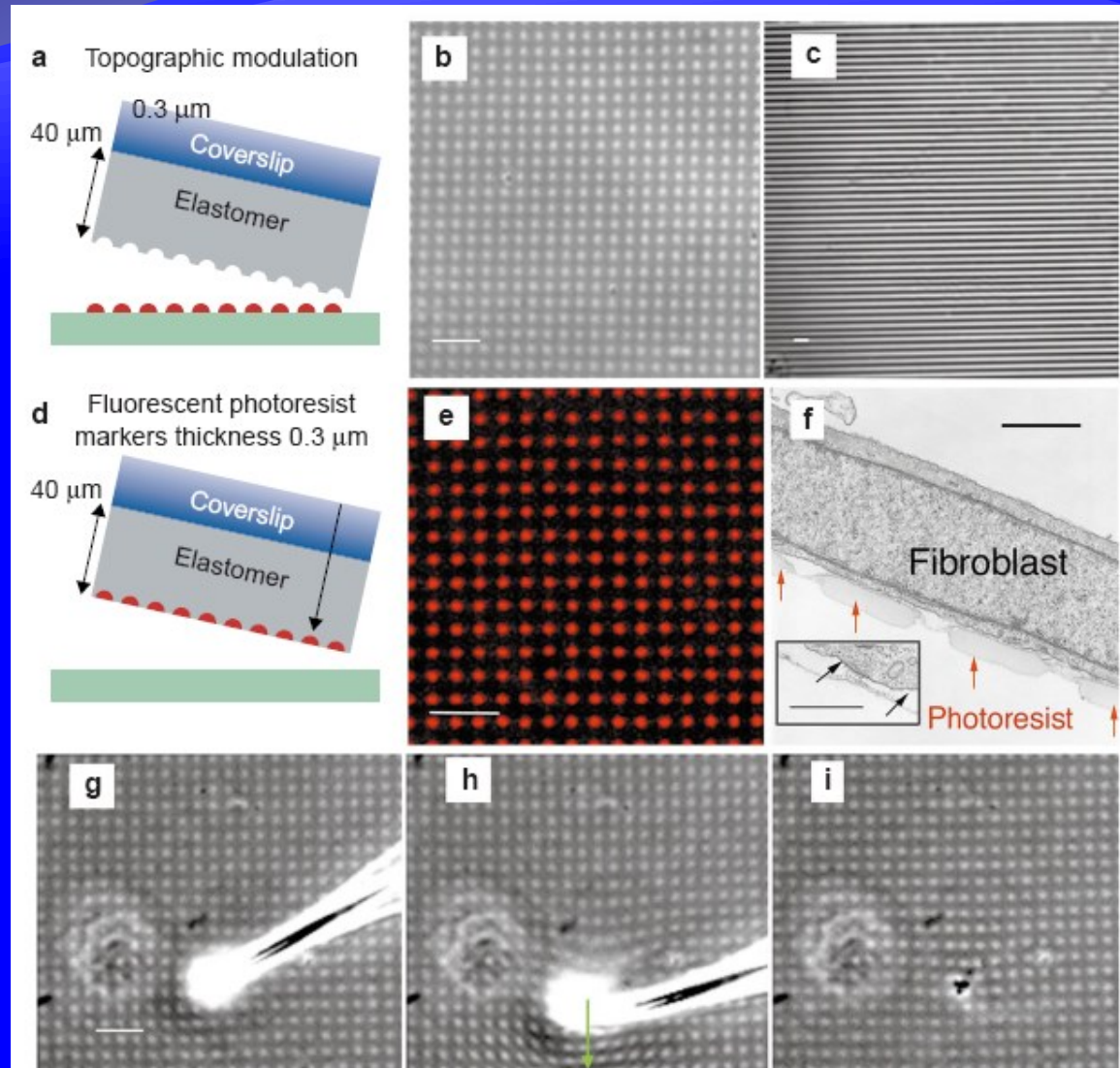
Cardiomyocyte Contraction

Force measured at focal adhesions

- ◆ Fibroblast transfected with cDNA for GFP-vinculin fusion protein

Traction Forces increase Focal Adhesion Structure: Spatiotemporal Correlation

◆ BDM relaxation at t=0 causes decreased focal adhesion area and intensity