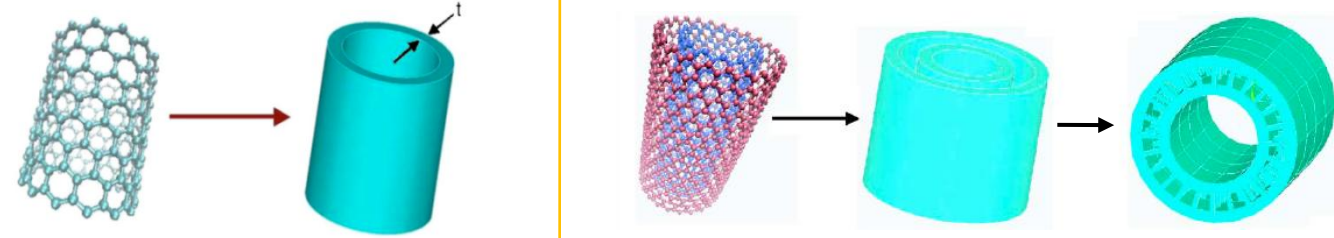


Carbon Nanotubes (CNT)

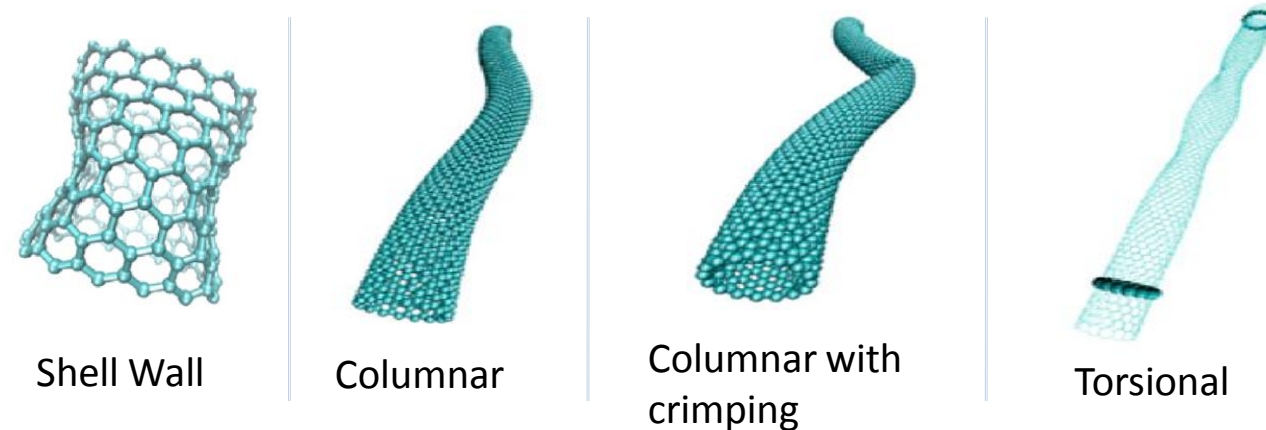
Equivalent continuum structure



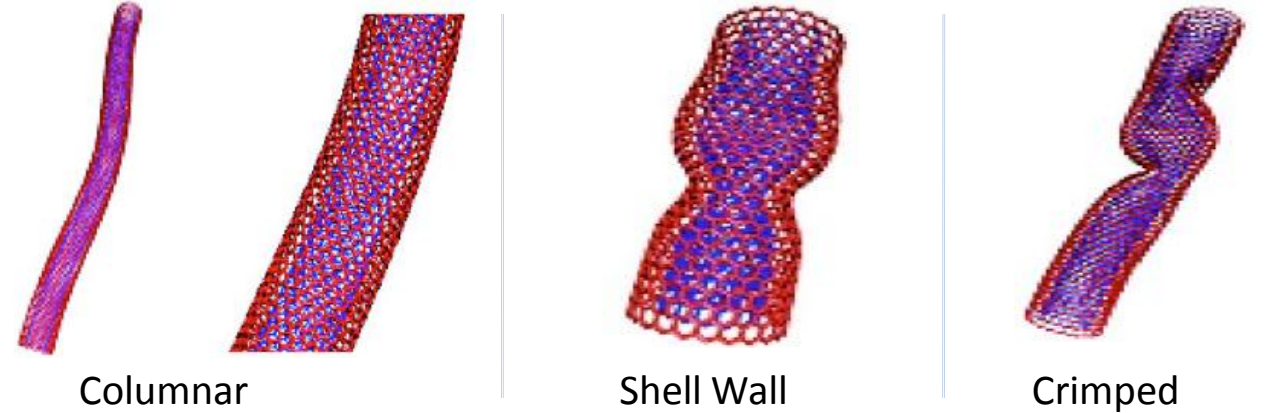
Single walled CNT – Hollow cylinders

Multiwalled CNT – tubes connected by trusses

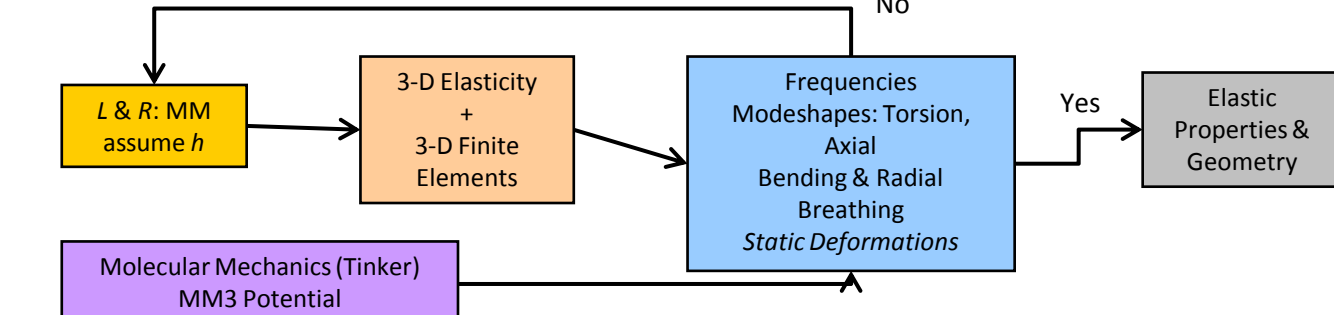
Buckling modes for a single walled CNT using molecular mechanics



Buckling modes for a multi-walled CNT using molecular mechanics



Vibration Analysis



Vibration Analysis – Torsion and Breathing modes

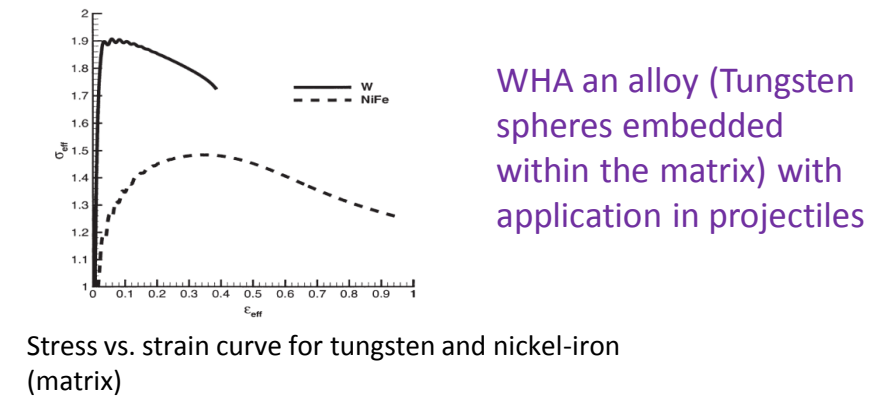
MM [cm ⁻¹]	3D FE [cm ⁻¹]
22.270	22.268
209.008	206.493
209.166	209.578

Vibration Analysis – Bending modes

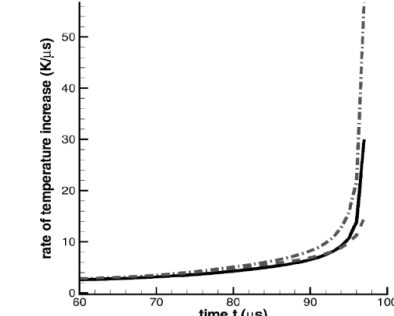
MM [cm ⁻¹]	3D FE [cm ⁻¹]
5.513	5.546
14.472	14.552
26.624	26.763

A. Sears and R. C. Batra, *Physical Review B*, **69** (2004) 235406
 A. Sears and R. C. Batra, *Physical Review B*, **73** (2006) 085410
 R. C. Batra and A. Sears, *International Journal of Solids and Structures*, **44** (2007) 7577-7596
 R. C. Batra and A. Sears, *Modeling and Simulation in Materials Science and Engineering*, **15** (2007) 835-844

Adiabatic Shear Bands (ASB)



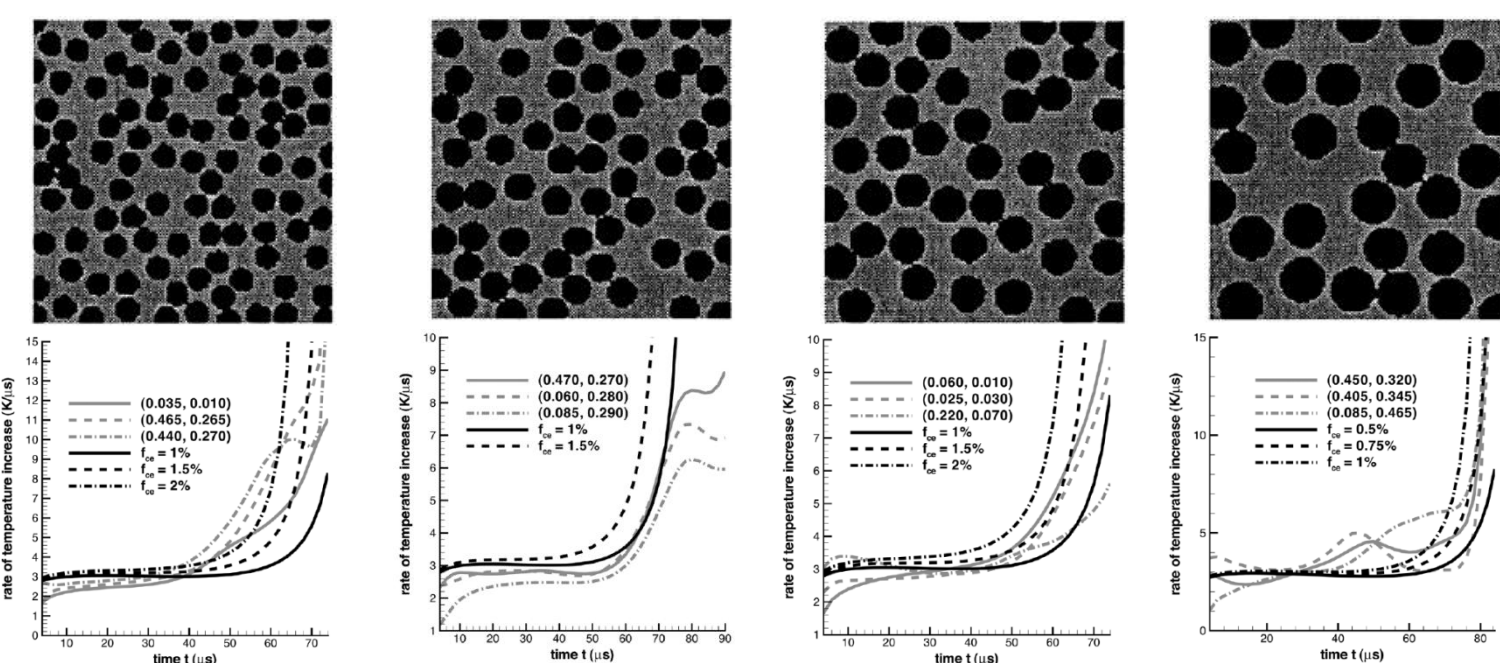
ASB initiation criteria



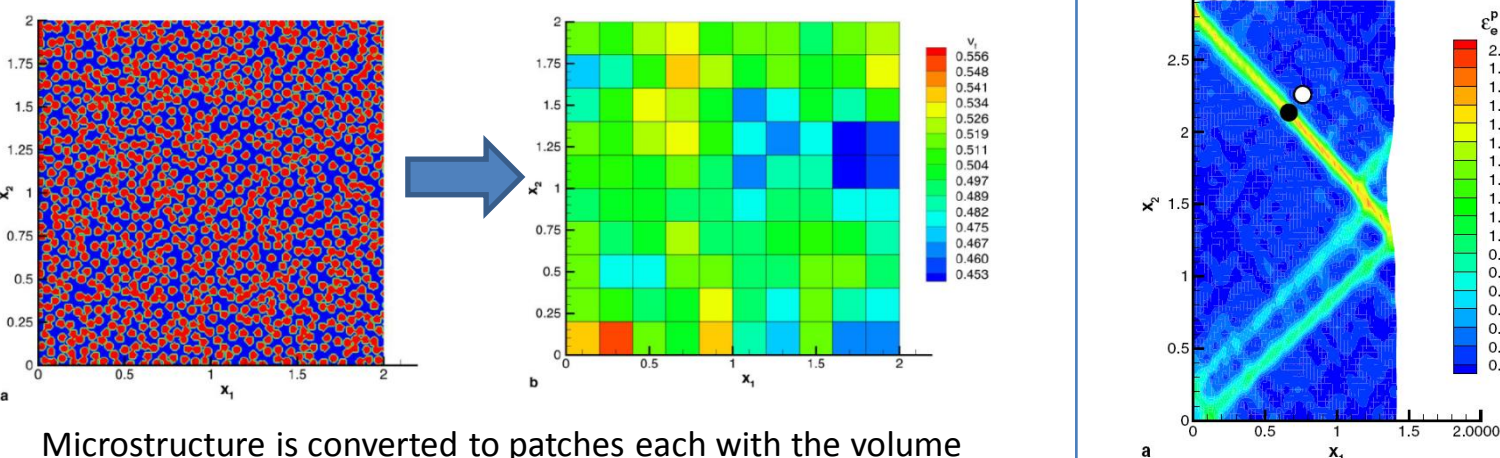
Stress vs. strain curve for tungsten and nickel-iron (matrix)

When rate of temperature increase at a point shows a jump

Effect of the Size of Tungsten Spheres



Microstructural Effects

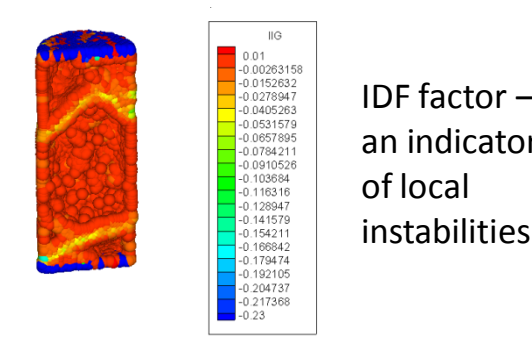
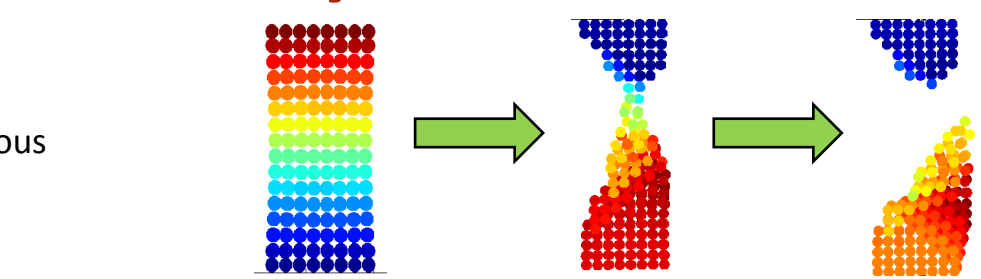
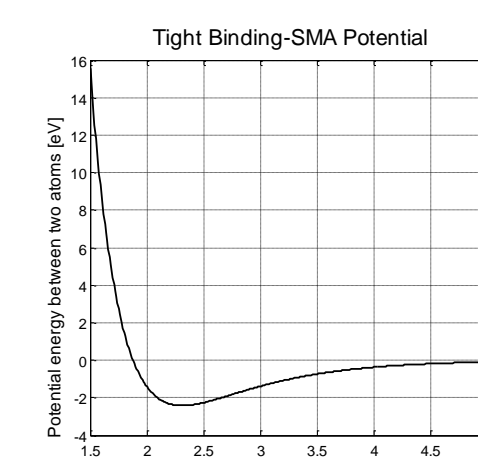


Microstructure is converted to patches each with the volume fraction of the region
 ASB initiation times in both cases was close

R. C. Batra and B. M. Love, *International Journal of Plasticity* **22** (2006) 1858-1878
 R. C. Batra and B. M. Love, *Journal of Thermal Stresses* **28** (2005) 747-782
 R. C. Batra and M. H. Lear, *International Journal of Plasticity* **21** (2005) 1521-1545
 R. C. Batra and W. G. Zei, *International Journal of Impact Engineering* **32** (2006) 947-967
 B. M. Love and R. C. Batra, *International Journal of Plasticity* **22** (2006) 1026-1061

Instabilities in Atomic Systems

Determination of conditions for nucleation of local instabilities
 Deformation of non-homogeneous regions

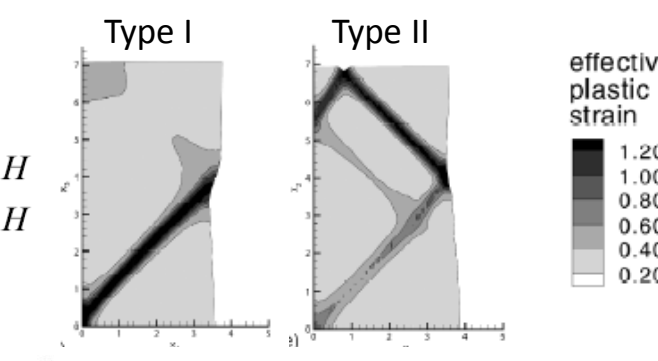


Functionally Graded Materials (FGM)

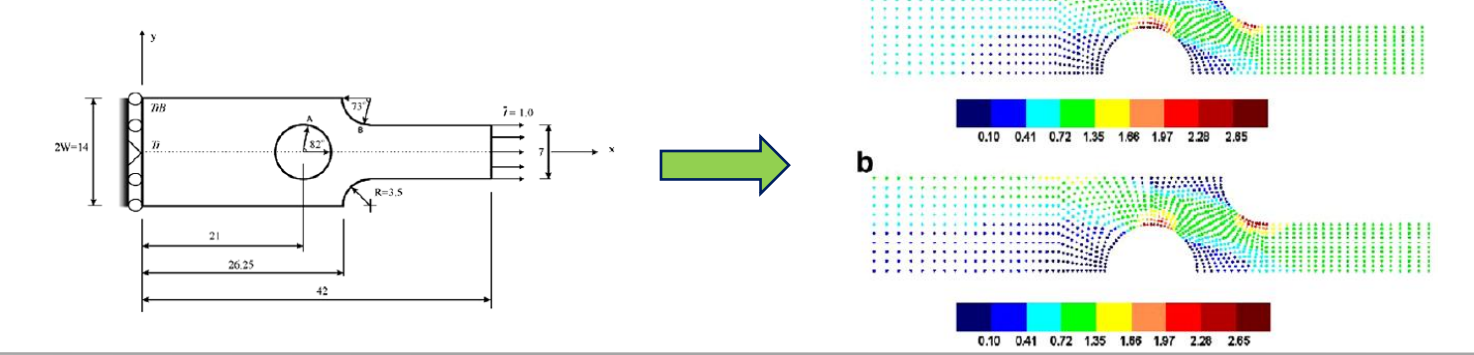
ASB in FGMs

$$v_{f,NiFe} = \begin{cases} c_f \frac{r}{H} & r \leq H \\ c_f & r \geq H \end{cases} \quad \text{Type I}$$

$$v_{f,NiFe} = \begin{cases} c_f (1 - \frac{r}{H}) & r \leq H \\ 0 & r \geq H \end{cases} \quad \text{Type II}$$



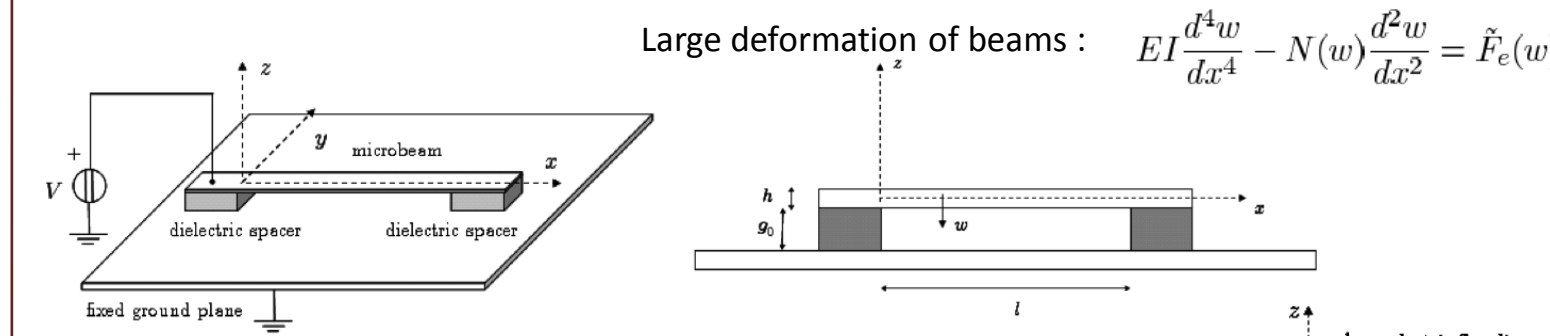
Analysis of FGM using MLPG method



R. C. Batra and B.M. Love *Journal of Thermal Stresses* **28** (2005) 747-782
 D. F. Gilhooly, J. R. Xiao, R. C. Batra, M. A. McCarthy, and J. W. Gillespie *Computational Materials Science* (accepted)
 G. M. Zhang and R. C. Batra *Journal of Computational Physics* **222** (2007) 374-390
 A. J. M. Ferreira, R. C. Batra, C. M. C. Roque, L. F. Qian, and R. M. N. Jorge *Composite Structures* **75** (2006) 593-600
 R. C. Batra *AIAA Journal* **44** (2006) 1363
 Z. H. Jin and R. C. Batra *Journal of Mechanics and Physics of Solids* **44** (1996) 1221-1235
 R. C. Batra and J. Jin *Journal of Sound and Vibrations* **282** (2005) 509-516

Micro-Electro-Mechanical Systems (MEMS)

1D model for Narrow Electrically Actuated Microbeams



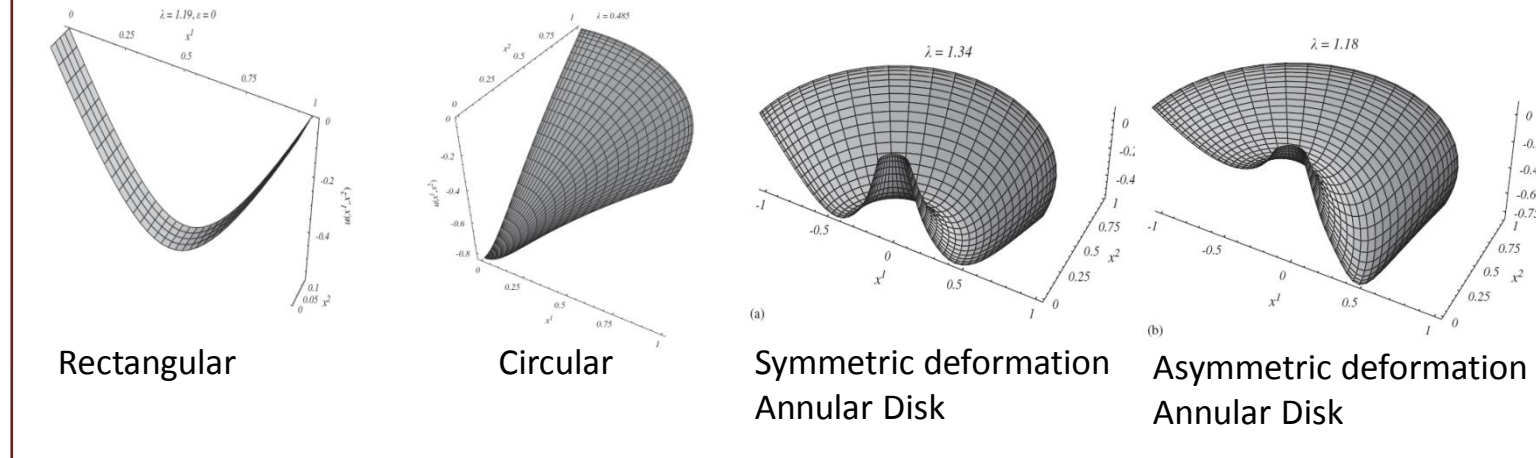
Electrostatic force:

$$\tilde{F}_e = -\frac{1}{2} V^2 \frac{\partial C_g}{\partial g}$$

$$C_g = \epsilon_0 \epsilon_r \left(\frac{\eta}{\beta} + c_0 + c_1 \left(\frac{\eta}{\beta} \right)^2 + c_3 \eta^4 \right)$$

Accounts for fringing fields from all surfaces

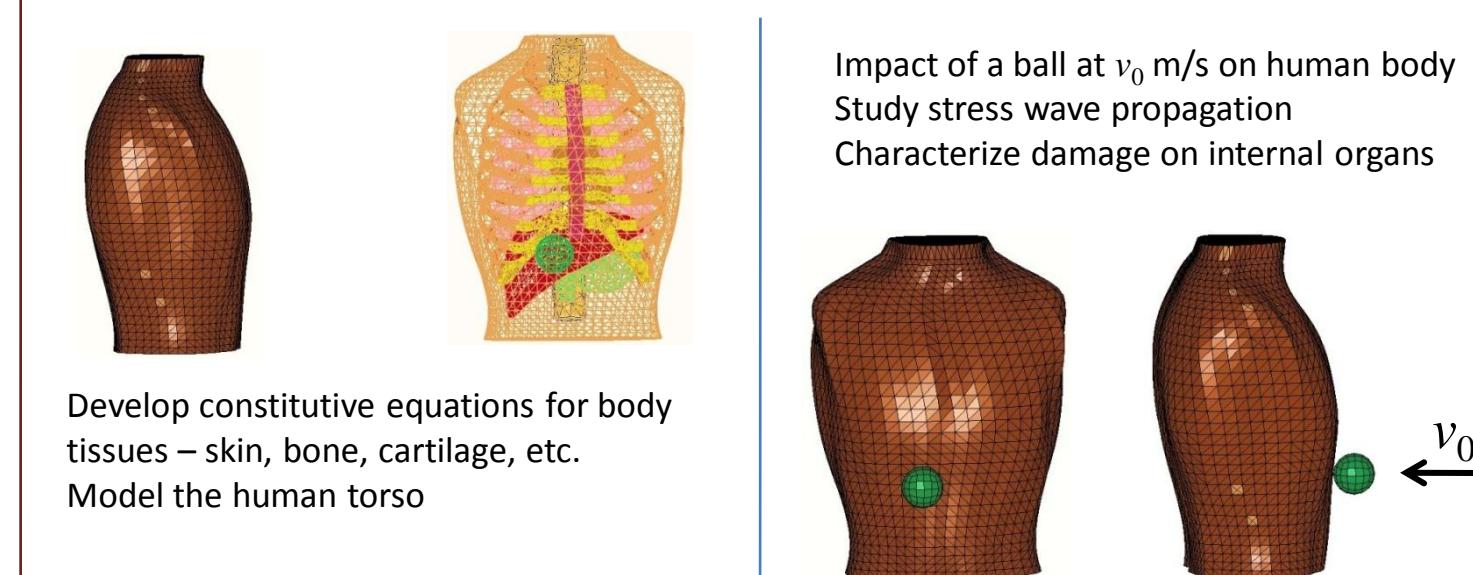
Pull-in instabilities of electrostatic MEMS using MLPG method



R. C. Batra, M. Porfiri, and D. Spinello *Journal of Microelectromechanical Systems* **15** (2006) 1175
 R. C. Batra, M. Porfiri, and D. Spinello *Engineering Analysis with Boundary Elements* **30** (2006) 949
 R. C. Batra, M. Porfiri, and D. Spinello *Micro & Nano Letters* **1** (2007) 71
 R. C. Batra, M. Porfiri, and D. Spinello *Europhysics Letters* **77** (2007) 20010
 R. C. Batra, M. Porfiri, and D. Spinello *Journal of Sound and Vibrations* **309** (2008) 600
 R. C. Batra, M. Porfiri, and D. Spinello *Smart Materials and Structures* **16** (2007) 23

Biomechanics

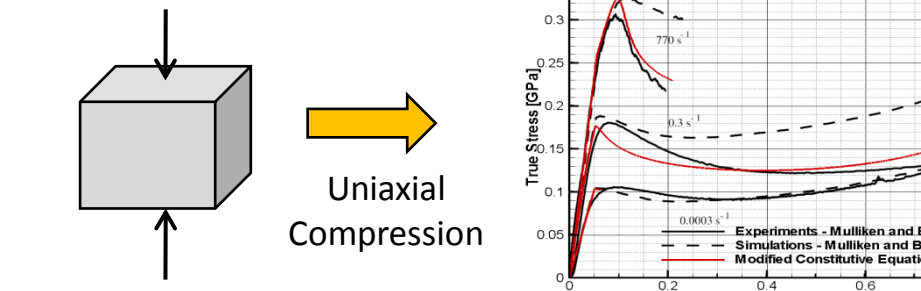
Analysis of Damage in Human Tissue due to Impact



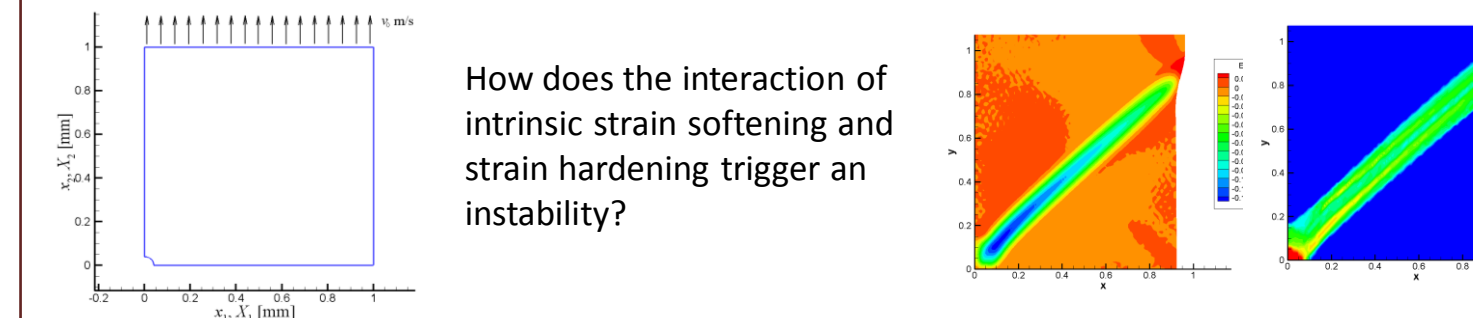
Transparent Polymers

Constitutive Equations for poly methyl methacrylate (PMMA)

Constitutive equations to predict thermo-mechanical response of PMMA at high strain rate (none reported in literature)



Instabilities in Transparent Polymers



Nanoindentation

