TAM 524 Micromechanics of Materials

CRN: 38772
Instructor : Prof . Huseyin Sehitoglu, huseyin@illinois.edu
Prerequisites: TAM 551 or equivalent
Class Time: MW 2:00-3:50 pm, Room 256 MEB, Office: Room 250 MEB
Office Hours: Open
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Coverage:

1. Elasticity and Eshelby Theory

1.1 Elasticity Theory - Overview
1.2 Eigenstrains, Green's functions
1.3 Elastic Inclusions and Inhomogeneities - The Eshelby approach
1.4. Energies of Inclusions

2. Deformation Mechanisms, Metallic Alloys

2.1 Martensitic Phase Transformations in Metals, Experiments and Models
2.2. Theories of Slip, Twinning
2.2 Solute Hardening
2.3 Coherency Hardening
2.4 Single Crystal, Polycrystal Experiments and Theories, Transition to Non-continuum
2.5 Self- Consistent Method, Mori-Tanaka Theory

3. Deformation Mechanisms, Metal Matrix and Ceramic Matrix Composites

3.1 Overall Response of Composites, Strengthening Mechanisms
3.2 Brown Dispersion Hardening
3.3Transformation Toughening Mechanisms in Brittle Composites
3.4Residual Stresses in Composites

4. Advanced Topics

4.1 External Fields
4.2 Treatment of Anisotropy
4.3 Interaction of Inclusions
4.4 Colonetti Theorem

Text:

T. Mura, Micro-mechanics of Defects in Solids, Kluwer, 1993 (available for download from UIUC library)

Recommended Textbooks:

1. R. Christensen, Mechanics of Composite Materials, Wiley, 1979
2. .J. Qu, M. Cherkaoui, Fundamentals of Micromechanics of Solids, Wiley, 2006 (e-book available UIUC)
3. W. Yang, W. Lee, Mesoplasticity and its Applications, Springer Verlag, 1993
4. E. Nembach, Particle Strengthening of Metals and Alloys, J. Wiley, 1997
5. D. Francois, A. Pineau, A. Zaoui, Comportement Mecanique des Materiaux, Hermes, 1995
6. A.S.Argon, Strengthening Mechanisms in Crystal Plasticity, Oxford, 2008

The class notes will not correspond exactly to text material (T. Mura). We will make references to the above texts and others during course coverage.

Grade :
Homework: 30%, Mid-Term : 20%, Final : 25%, Project: 25%
Late homework will not be accepted. Cell phones, i-pads, and computers need to be in silent mode and accessed only in the case of emergency or class project.

The Papers that Accompany the Micromechanics of Materials Course

1. Eshelby, J.D., Elastic Inclusions and Inhomogeneities, Progress in Solid Mechanics, Editors I. Sneddon, R.Hill, North Holland (1961), 89-140.
2. Eshelby, J.D., The Determination of the Elastic Field of an Ellipsoidal Inclusion, and Related Problems, *Proc. R. Soc. London. A*, 20, 1957 241 1226, 376-396, dowloadable from http://web.mit.edu/course/3/3.064/www/slides/Eshelby_1957.pdf
3. N. Hatcher, O. Yu. Kontsevoi, and A. J. Freeman, Role of elastic and shear stabilities in the martensitic transformation path of NiTi, Physical Review B 80, 144203 , 2009.
4. J.R. Patel, M. Cohen, Criterion for the action of applied stress in the martensitic transformation, Acta Metallurgica, 1, 5, 531-538, 1953.
5. V. Gerold and H.Haberkorn, On the Critical Resolved Shear Stressof Solid Solutions Containing Coherent Precipitates, Phys. stat. sol. 16, 675, 1966
6. Taylor, G. I. and C. F. Elam, The Distortion of an Aluminum Crystal During a Tensile Test, *Proc. Roy. Soc.,* Vol. A102, 647, 1923
7. A.G.Evans, A.H.Heuer, Review-Transformation Toughening in Ceramics: Martensitic Transformations in Crack-Tip Stress Fields, J. of the American Ceramic Society, 63, *5-6*, 241-248, 1980
8. R.M.McMeeking, A.G.Evans, Mechanics of Transformation-Toughening in Brittle Materials, Journal of the American Ceramic Society-, 65, 5,242-246, 1981
9. L. M. Brown, W. M. Stobbs , The work-hardening of copper-silica I. A model based on internal stresses, with no plastic relaxation, *Philosophical Magazine*, Vol. 23, (1971), 1185-1199
10. E. Patoor, M. El Amrani, A. Eberhardt and M. Berveiller, Determination of the Origin for the Dissymmetry Observed between Tensile and Compression Tests on Shape Memory Alloys, Journal de Physique IV Colloque C2, Supplement of Journal de Physique IV, 495-500, 1995
11. R.M.Christensen, K.N.Lo, Solutions for Effective Shear Properties in Three Phase Sphere and Cylinder Models, JMPS,27, 315-330, 1979
12. M.Kumosa, Strain energy of a mechanical twin in alpha -iron J. Phys. D: Appl. Phys. 24 1816, 1991

Class Website:
http://html.mechse.illinois.edu/classes/