The University of Michigan

Department of Mechanical Engineering

ME 586 – Fall 2009

Laser Materials Processing

COURSE CONTENTS

Week	Outline	Reading – Problems
Week 1	Introduction	Chapter 14: 14.1, 14.2, 14.3, 14.5
Week 2, 3	Laser Cutting/Drilling	Chapter 15: 15.1, 15.3, 15.4, 15.9
Week 4, 5	Laser Welding	Chapter 16: 16.1, 16.6, 16.8, 16.9
Week 6, 7	Laser Surface Modification	Chapter 17: 17.3, 17.4, 17.5, 17.6
Week 8	Laser Forming	Chapter 18: 18.1, 18.2, 18.3, 18.4
Week 9	Rapid Prototyping	Chapter 19: 19.3, 19.4, 19.5, 19.7
Week 10, 11	Thermal Aspects	Chapter 10: 10.1, 10.2, 10.10, 10.12
Week 12	Metallurgical Issues	Chapter 11: 11.7, 11.9, 11.10, 11.11
Week 13	Residual Stresses and Distortion	Chapter 13: 13.2, 13.5, 13.13, 13.14
Week 14	Process Monitoring	Chapter 21

TEXTBOOK: **Principles of Laser Materials Processing**, by *Elijah Kannatey-Asibu, Jr.*
John Wiley & Sons, Inc., Hoboken, N.J.

COURSE GRADE:

Homework	25 %
Term Projects	25 %
Midterm	25 %
Final	25 %

LECTURES: M, W: 8:30-10:00 a.m.

INSTRUCTOR: Prof. Kannatey-Asibu, Jr.

Office Hours: M, W: 3:00-4:00 p.m.

Office: 3134 GGBrown. Phone: 936-0408

e-mail: asibu@umich.edu

All reading assignment must be completed ahead of time.

No make-up exams.

REFERENCES

Chryssolouris, G., 1991, *Laser Machining,* Theory and Practice, Springer-Verlag, Berlin.

Duley, W. W., 1982, *Laser Processing and Analysis of Materials,* Plenum Press, New York.

Harry, John, E., 1974, *Industrial Lasers and their Applications*, McGraw Hill, London.

Steen, W. M., 2003, *Laser Material Processing,* Springer-Verlag, Berlin.

Wilson, J., and Hawkes, J. F. B., 1987, *Lasers - Principles and Applications*, Prentice Hall International Series in Optoelectronics, New York.

IN-CLASS PROJECTS

1. Prepare a 5-page double spaced analysis of two selected chapters of the book.
2. Also, prepare solutions to the problems in the boldfaced chapter.

One of the following chapter combinations may be selected:

1 and 13

2 and 23

3 and **16**

4 and 15

5 and 17

6 and 18

7 and 19

8 and 20

9 and 21

10 and 14

11 and 22

12 and 14

Each student will have to work on a different chapter combination. Chapter selection will be on a first come first, served basis.

LASER MATERIALS PROCESSING

Laser Welding

Mechanism of laser welding
Conduction mode welding
Key-hole welding
Welding performance and quality
Comparison with conventional welding operations
Components of a laser welding system
Examples of applications

Laser Welding – The student will understand the fundamental issues related to laser welding, current research topics, and applications for laser welding. Details include: mechanism of laser welding; conduction mode welding; key-hole welding; absorption mechanisms, viz., Fresnel and inverse bremsstrahlung absorption; influence of the shielding gas and plasma plume; welding performance and quality; comparison with conventional welding operations; response of different materials to laser welding; components of a laser welding system; research issues in laser welding; single beam laser welding as compared with the new concepts of multiple beam and arc-augmented laser welding; examples of applications.

Laser Machining (Cutting)

Mechanism of laser machining
Laser cutting techniques
Cutting performance and quality
Comparison with conventional machining operations
Components of a laser machining system
Drilling, scribing and marking
Laser cutting of plastics, composites, and other materials
Examples of applications

Laser Machining (Cutting) – The student will understand the basic concepts of laser cutting, current research issues in this area, and applications of laser cutting. Details include: different modes of cutting, viz. fusion and sublimation cutting, and photochemical ablation; mechanism of laser machining -- analysis of the gas flow, flow of the molten metal, and conditions for striation and dross formation; laser cutting techniques; cutting performance and quality; comparison with conventional machining operations; components of a laser machining system; types of assist and shielding gases, and the different types of nozzles; different forms of laser drilling, viz., percussion drilling and trepanning; scribing and marking; laser cutting of plastics, composites, and other materials; examples of applications.

Laser Surface Modification

Mechanism of laser heat treatment
Surface melting, alloying
Laser cladding
Laser chemical vapor deposition
Laser physical vapor deposition
Stereolithography
Paint stripping

Laser Surface Modification – This module will provide the student with a fundamental background on the various forms of laser surface modification. Details include: mechanism of laser heat treatment; surface melting, alloying; laser cladding; laser chemical vapor deposition; laser physical vapor deposition; stereolithography; paint stripping.

Heat and Fluid Flow
Analysis of temperature distribution in weldments
Energy equation
Point and line heat source analyses
Finite element analysis
Thermal cycle, Peak temperatures, Cooling rates
Continuity and Momentum equations
Marangoni convection
Active element effect
Multiple-beam effect
Heat and Fluid Flow – This module will enable the student acquire a basic understanding of the thermal and/or fluid flow issues related to laser welding, cutting, heat treatment. Details include: analysis of temperature distribution; energy equation; point and line heat source analyses; finite element analysis; thermal cycle, peak temperatures, cooling rates; continuity and momentum equations; marangoni convection; solidification with and without flow; active element effect; multiple-beam effect.

Microstructural Issues
Process microstructure
Solidification criterion
Zone of partial melting
Heat affected zone microstructure
Application to specific materials
Discontinuities
Microstructural Issues – The student will acquire a fundamental understanding of the metallurgical issues that arise during laser processing, and how those influence the mechanical properties of the material. Details include: weld bead microstructure; solidification criterion; zone of partial melting; heat affected zone microstructure; application to specific materials; discontinuities; Monte Carlo simulation of microstructure.

Residual Stresses and Distortion
Basic causes of residual stresses
Compatibility equation
Measurement of residual stresses
Distortion
Residual stress relief
Residual Stresses and Distortion – The discussion on this module will give the students an understanding on the causes and mechanics of residual stress and distortion that arise during welding and heat treatment. Details include: basic causes of residual stresses; compatibility equation; measurement of residual stresses; distortion; residual stress relief.

Process monitoring
Laser beam monitoring
Plasma monitoring
Process monitorings
Signal Processing
Joint tracking
Process Monitoring – This module will discuss the various forms of process monitoring and the appropriate conditions under which they are applicable, and their basis for process control. Details include: laser beam monitoring; plasma monitoring; process monitoring; signal processing methods.