

Extreme Ultraviolet and X-Rays Lasers: Principles and Applications

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Course description: We will review the generation, properties, and use of extreme-ultraviolet (EUV) and x-ray laser radiation—a region of the spectrum that is rapidly emerging as an indispensable tool for science and technology. Applications of EUV and soft x-ray laser light range from basic science, to ultrahigh-resolution microscopy, the development new material nanopores, nano-patterning and nano-machining techniques. This course will review fundamental physical concepts, the state of the art of sources designed to produce EUV and soft x-ray laser radiation, and the optics designed to manipulate it. The last part of the course will discuss applications.

Grading: Course grade will be based on homework problems, and on a paper (10-15 pages) and presentation (~20 minutes) on a topic of relevance to the course

Course outline:

1. Introduction

EUV and soft x-ray regions of the electromagnetic spectrum

Basic absorption and emission processes

Atomic energy levels and allowed transitions.

Scattering, diffraction and refraction of electromagnetic radiation

2. Laser Created Plasmas.

Basic parameters for describing a plasma

Physics of dense plasmas

Plasma models

X-Ray emission from hot dense plasmas

Spectroscopy of dense plasmas

Density gradients and EUV probing of plasmas

3. Extreme ultraviolet and X-Ray Lasers

Amplification of radiation

Laser-pumped collisional lasers.

Discharge pumped collisional lasers

Recombination lasers.

Inner-shell photoionization lasers

Approaches to practical table-top lasers

X-ray free-electron lasers

Injection-seeded soft x-ray lasers

4. Soft x-ray optics

Reflection and refraction of soft x-ray radiation.

Enhanced reflectivity from periodic structures.

Multilayer interference coatings.

Applications of multilayer coated optics.

Soft x-ray monochromators.

5. Applications of EUV and soft x-ray laser radiation

5.1 Soft X-Ray microscopy

Fresnel zone plate lens

Diffraction of radiation by pinhole apertures and zone plates

High resolution soft x-ray microscopy and application

Movies of nano-scale phenomena using soft x-ray laser light.

5.2 Soft X-Ray Laser Interferometry

Soft x-ray interferometers

High density plasma diagnostics with soft x-ray lasers

5.5. Nano-patterning and nano-machining with soft x-ray lasers

Interferometric lithography

Coherent Talbot printing

Laser nano-machining

5.4 Metrology for Extreme Ultraviolet lithography of the next generations of

Computer processors

Semiconductor circuits roadmap

Deep ultraviolet lithography and beyond

Extreme Ultraviolet lithography

5.5. Analytic Nano-probes

Nano-scale laser ablation

Mass spectrometry nanoprobes