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Short Course

MODERN LASER TECHNOLOGIES

Laser processing of materials: fundamentals and applications

Russian Academy of Sciences
A.M. Prokhorov General Physics Institute

Russian Academy of Sciences

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Alexander M. Prokhorov

- 1964 – Nobel Prize winner

  for fundamental investigations in quantum electronics that led to creation of lasers and masers

Конец 1965: А. М. Прохоров, Ч. Х. Таунс и Н. Г. Басов в Физическом институте Академии наук

Карл Август VI вручает диплом нобелевского лауреата и медаль А. М. Прохорову

Диплом нобелевского лауреата А. М. Прохорова

Нобелевская медаль А. М. Прохорова

Major Fields of Research

- Physics of condensed matter
- Optics and laser physics
- Radio-physics, electronics, and acoustics
- Plasma physics

Optics and laser physics

1. Classic and quantum optics
2. Nonlinear optical phenomena, materials and devices
3. Ultrafast phenomena in optics
4. Laser-matter interaction, laser technologies
5. Fiber optics and optical communication. Integrated optics.
6. Optical informatics and holography
7. Methods of spectroscopy and luminescence. Precision optical measurements
8. Laser physics and laser materials
9. Lasers in physics, chemistry, biology, medicine, ecology, and industry
10. New optical materials, technology and devices

Contents

1. Introduction
   - most important parameters of laser radiation;
   - modern technological lasers

2. Irradiation scemes:
   - beam focusing;
   - image projection;
   - diffractive optics;
   - scanning

3. Optical properties of materials:
   - reflectivity and absorbtivity, absorbtion coefficient and experimental techniques of their measurements;
   - difference between ideal and real optical surfaces;
   - interference phenomena;
   - role of temperature and phase transitions;
   - effective energy coupling regimes

4. Phenomena induced by low intensity radiation:
   - fluorescence;
   - generation of charged carriers;
   - photoemission of electrons;
   - photo and thermo desorbtion;
   - thermo diffusion;
   - surface electromagnetic waves

5. Laser heating of solids:
   - major parameters;
   - one-dimensional and spherical approximations;
   - useful expressions.

6. Thermoelastic surface deformations:
   - theoretical model;
   - short and long pulse approximations;
   - surface profile distortion;
   - irreversible material damage.

7. Laser ablation:
   - surface melting;
   - evaporation threshold;
   - steady-state ablation;
   - ablation without heat diffusion;
   - liquid material expulsion by vapour plume.

8. Laser induced surface structures:
   - examples;
   - resonant and non-resonant surface structures;
   - theoretical approach.

9. Laser-produced plasmas:
   - laser heating of ionized gases;
   - electron avalanche;
   - plasma formation in vapour plume;
   - vapour plasma expansion into vacuum;
   - optical gas breakdown;
   - laser supported absorbtion waves;
   - energy balance.

10. Surface chemical reactions:
   - classification;
   - photolitic processes;
   - pyrolitic reactions;
   - positive and negative feedback loops;
   - modeling;
   - gas transport limitation;
   - solid-liquid interface.

11. High-power laser applications:
   - surface melting and hardening;
   - laser welding and cutting;
   - laser propulsion;
   - laser ignition.

12. Laser micro and nanotechnologies:
   - surface cleaning;
   - photolithography;
   - laser induced phase-transformation, doping and annealing;
   - ablative and chemical etching;
   - CVD and PVD;
   - laser printing;
   - microdrilling;
   - surface profiling, polishing and structuring;
   - bulk structuring;
   - laser prototyping.

13. Laser medicine:
   - what is biotissue;
   - optical diagnostics and tomography;
   - phototherapy;
   - surgery;
   - lithotripsy;
   - ophthalmology.