MICRO-457

Materials processing with intelligent systems

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Cursus	Sem.	Type
Microtechnics	MA1, MA3	Opt.

Language of teaching	English
Credits	3
Session	Winter
Semester	Fall
Exam	Oral
Workload	90h
Weeks	14
Hours	**3 weekly**
Lecture	2 weekly
Exercises	1 weekly
Number of positions	

Summary

Repeatability in laser material processing is challenging due to high-speed dynamics. To address this issue, the course provides an overview of laser theory, laser-material interaction, various types of sensors (acoustic & optic), data acquisition, online monitoring, and control via machine learning

Content

The goal of this lecture is to acquaint students with approaches for the in situ and real-time process monitoring and control of highly dynamical processes. Given the generality of the topic, the content is very broad and can be divided into 5 sub-sections.
1) Laser processing. We will provide the basis of laser processing (laser theory, interaction laser-materials, type of laser, laser safety, various process (ablation, polishing, welding, …);
2) Sensors. State-of-the-art sensors (acoustic sensors, including piezo and optical fiber, and optical sensors, including spectroscopic detectors, photodiodes, …). For each type of sensors, we will provide industrial applications, theoretical background, advantages, disadvantages, and limitations.
3) Data acquisition. Information about various ways of acquiring data depending on the use and sensors selected. Mathematical foundations of signal discretization (sampling): Shannon Theorem and frequency analysis. Data storage and reconstruction without information loss.
4) Signal processing techniques. A short introduction/overview of the latest machine learning methods will be given (supervised, unsupervised, and reinforcement learning). Classification, clustering, and intelligent controllers.
5) Practical examples of combining (1) to (4) to have an in situ and real-time laser process monitoring and control unit.

Keywords

Laser processing, material processing, sensors, data acquistion, signal processing, machine learning, reinforcement learning.

Learning Prerequisites

Required courses

None, the lecture is self-contained.

Recommended courses

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Learning Outcomes

By the end of the course, the student must be able to:

- Integrate the laser-materials interaction

- Assess / Evaluate various type of sensors depending on the time scale of the process
- Argue on the use of sensors depending on applications
- Integrate Nyquist-Shannon sampling theorem
- Integrate concepts of time, frequency, time-frequency domains
- Recognize the various machine learning methods
- Decide methods appropriate to practical problems

Transversal skills

- Use a work methodology appropriate to the task.
- Set objectives and design an action plan to reach those objectives.

Teaching methods

Oral presentation + discussions, guided exercises and rehearsal

Expected student activities

1) Participate actively in the lecture
2) Carry out all exercises

Assessment methods

Final written exam (85% grade), in-class assessment (15% grade).

Supervision

Office hours	No
Assistants	No
Forum	No