Class Syllabus – Fall Semester, 115 Academic Year
Department of Mechanical Engineering, National Chung Cheng University

<table>
<tr><td colspan="4">Course Name: 雷射定義功能性碳系材料
Laser-Defined Functional Carbon-Based Materials</td><td colspan="2">Dept.</td><td>ME</td></tr>
<tr><td colspan="4"></td><td colspan="2">Course Code</td><td>4205117</td></tr>
<tr><td>Instructors</td><td>Yi-Hung Chen</td><td>Credits</td><td>3</td><td>Compulsory
/Elective</td><td>Grade</td><td>Master's program</td></tr>
<tr><td>EMI</td><td colspan="6">■ Yes □ No</td></tr>
</table>

Prerequisites:
Basic knowledge of materials science, manufacturing processes, and engineering analysis is recommended. Prior experience with laser processing, thin film processing, or nanomaterials is helpful but not required.

Class Description:
This graduate-level course introduces laser-defined functional carbon-based materials from the viewpoints of laser processing, carbon material growth, patterned structures, characterization, and device applications. The course emphasizes how localized laser energy can be used to define patterns, modify surfaces, assist material transfer, activate catalytic regions, and support the selective growth or integration of carbon-based materials. Carbon nanotubes, graphene, amorphous carbon, diamond-like carbon, carbon nanowalls, and laser-induced carbon materials will be discussed. Field emission is used as a representative application to connect material structure, patterned geometry, and functional device performance.

Class Objective:
1. Explain laser-material interaction and its role in pattern definition.
2. Compare major carbon-based materials, their growth mechanisms, and their functional properties.
3. Interpret characterization results related to structure, morphology, electrical properties, and field emission behavior.
4. Analyze how patterned carbon structures contribute to applications such as field emitters, electrodes, sensors, and microdevices.
5. Develop literature-based application case studies and an integrated final proposal for patterned carbon material systems.

Textbooks	Required textbook: None. Course materials will be provided through instructor-prepared slides, selected journal papers, and self-edited handouts. Suggested references include textbooks and review papers on laser materials processing, carbon nanomaterials, thin film processing, vacuum microelectronics, and field emission devices.

An overview of the main points of teaching

Teaching Materials	■ PPT ■ Self-edited textbooks □ Self-made instructional videos	■ Course handouts ■ Teaching Procedures ■ Other: Selected journal papers
Teaching Methods	■ Lectures ■ Oral presentation ■ Case studies	■ Group discussion ■ Problem-oriented learning ■ Other: Guided practical design and data analysis

<table>
<tr><td>Evaluation Tools</td><td colspan="6">■ Mid-term Exam □ Final Exam
□ In-class Quiz □ In-class homework
□ Homework □ Mid-term Report
■ Final Report ■ Special Report
□ Other □ Scales</td></tr>
<tr><td>Teaching Resources</td><td colspan="6">■ Course website
■ Electronic files of course materials are available for download
□ Internship website</td></tr>
<tr><td>Instructor's Information</td><td colspan="6">Yi-Hung Chen, Assistant Professor
Department of Mechanical Engineering, National Chung Cheng University
E-mail: yihungchen@ccu.edu.tw
Office hour: By appointment</td></tr>
<tr><td colspan="2">Course Outlines</td><td colspan="4">Teaching Hours</td><td rowspan="2">Core Competence</td></tr>
<tr><td>Unit Title</td><td>Contents</td><td>Lectures</td><td>Demo</td><td>Practice</td><td>Other</td></tr>
<tr><td>Laser-material interaction and pattern definition</td><td>Course orientation; laser wavelength, absorption, reflection, thermal effect, pulse duration, energy density, scan parameters, overlap, resolution, and laser-induced local processing.</td><td>12</td><td>0</td><td>0</td><td>0</td><td>D1, D2, D4</td></tr>
<tr><td>Carbon-based materials and patterned growth</td><td>Graphite, graphene, CNT, amorphous carbon, DLC, carbon nanowalls, CVD, PECVD, MPCVD, catalyst-assisted growth, nucleation control, patterned catalyst layers, selective growth, and localized growth.</td><td>9</td><td>0</td><td>0</td><td>0</td><td>D1, D2, D4</td></tr>
<tr><td>Characterization, functional evaluation, and field emission fundamentals</td><td>Raman spectroscopy, SEM, TEM, AFM, surface morphology, sheet resistance, conductivity, work function, local electric field, field enhancement factor, Fowler-Nordheim theory, and turn-on field.</td><td>6</td><td>0</td><td>0</td><td>0</td><td>D1, D2</td></tr>
<tr><td>Patterned carbon materials practice and mid-term exam</td><td>Guided design of patterned carbon materials, process planning, laser path concept, geometry definition, analysis of pattern quality, morphology, Raman or electrical data, and mid-term exam.</td><td>0</td><td>2</td><td>4</td><td>3</td><td>D2, D3, D4, D7</td></tr>
</table>

Field emission applications and final integration	Carbon-based field emitters, device structure, vacuum measurement, current density, emission stability, patterned device examples, final integrated report, and course conclusion.	6	0	0	6	D1, D2, D3, D4, D6, D9

Achievable Core Competence	Achievable Objective
D1	Students will be able to explain fundamental concepts of laser processing, carbon-based materials, characterization methods, and field emission mechanisms.
D2	Students will be able to plan an integrated research workflow for patterned carbon materials, including process design, structure control, characterization, and functional evaluation.
D3	Students will be able to read, organize, and present scientific literature related to patterned carbon material applications.
D4, D6, D9	Students will be able to develop creative application concepts while considering international research trends, engineering ethics, and sustainable development.

The core competence of the Institute

D1 has expertise in the field of mechanical and opto-mechanical integration engineering

D2 Ability to plan and execute special research projects in the field of mechanical and opto-mechanical integration engineering

D3 Ability to write scientific papers and presentations

D4 Ability to think creatively and solve mechanical and opto-mechanical integration engineering problems independently

D5 Ability to coordinate and integrate cross-disciplinary personnel

D6 Good international outlook

D7 has team spirit and the ability to lead, manage, plan and communicate

D8 Ability of lifelong self-learning and growth

D9 Understand the importance of engineering ethics, social responsibility and sustainable development

<table>
<tr><th colspan="5">Weekly teaching plan</th></tr>
<tr><th>Course Time</th><th>Course Location</th><th>Grading</th><th>Office hour</th><th>Teaching quality evaluation method</th></tr>
<tr><td>Thursday
10:10~13:00</td><td>ME 214R</td><td>Mid-term Exam 20%
Application Case Study Report 35%
Final Integrated Report 30%
Participation and Discussion 15%</td><td></td><td>Questionnaire</td></tr>
<tr><th>Weeks</th><th colspan="3">Teaching & Homework Progress</th><th>Note</th></tr>
<tr><td>1</td><td colspan="3">Introduction</td><td></td></tr>
<tr><td>2</td><td colspan="3">Fundamentals of laser-material interaction</td><td></td></tr>
<tr><td>3</td><td colspan="3">Laser processing parameters and pattern definition</td><td></td></tr>
<tr><td>4</td><td colspan="3">Laser-induced modification and local material processing</td><td></td></tr>
<tr><td>5</td><td colspan="3">Fundamentals of carbon-based materials</td><td></td></tr>
<tr><td>6</td><td colspan="3">Growth mechanisms of carbon nanomaterials</td><td></td></tr>
<tr><td>7</td><td colspan="3">Patterned carbon materials and selective growth</td><td></td></tr>
<tr><td>8</td><td colspan="3">Characterization and functional evaluation</td><td></td></tr>
<tr><td>9</td><td colspan="3">Field emission fundamentals</td><td></td></tr>
<tr><td>10</td><td colspan="3">Patterned carbon materials practice I</td><td></td></tr>
<tr><td>11</td><td colspan="3">Patterned carbon materials practice II</td><td></td></tr>
<tr><td>12</td><td colspan="3">Mid-term exam</td><td></td></tr>
<tr><td>13</td><td colspan="3">Carbon materials for field emission applications</td><td></td></tr>
<tr><td>14</td><td colspan="3">Field emission device structure and measurement</td><td></td></tr>
<tr><td>15</td><td colspan="3">Final integrated report I</td><td></td></tr>
<tr><td>16</td><td colspan="3">Final integrated report II</td><td></td></tr>
</table>