**ECE 536 – Spring 2022**

**Final Project Information**

The goal of the final project is to explore in more depth a topic related to the class material. There are several possible choices:

1) A study on the state-of-the art of a specific topic/technology of interest, possibly with formulation of some personal ideas, observations, and conclusions on the subject (this tends to be the preferred activity for a majority of students).
2) A more analytical effort involving the study of a theory of interest, which may result in the development of a model and/or of an analysis/extension/test of a theoretical aspect.
3) Study of a computational/modeling technique with development of an original software or in alternative an investigation with available application software, for a topic of interest within the scope of the course.

**The final project should produce the following:**

1) **A final presentation (10 minutes) to be given at the time scheduled for the final exam**
2) **A final paper/report**
3) **Any other pertinent product (e.g., software, data, etc.) as appropriate**

An incomplete list of suitable topical areas for the final project/paper is given below. Students can also propose their own topic. which would be typically approved if within the scope of the course. The main stipulation is that, if related to the thesis work pursued by the student, the project should be "complementary" to it and it should not duplicate/report on work already performed toward the thesis. Also, it should not consist of material already used for presentation in another class.

**Materials Growth and Processing**

__MBE growth of quantum confined structures (quantum wells, wires, dots)
__MOCVD growth of quantum confined structures (quantum wells, wires, dots)
__Progress on lattice-mismatched growth for heterogeneous integration on silicon

**Semiconductor Lasers**

__Mid-IR type-I quantum-cascade lasers
__VCSELs, high speed (beyond 10 Gb/s)
__Microcavity and nanocavity lasers
__GaN-based blue-green lasers and LEDs.
__Quantum-well (QW) lasers with important applications
__Quantum-dot (QD) lasers for new applications

**Modulators**

__Electroabsorption modulators at 40 Gb/s
__Waveguide modulators - high speed 40 Gb/s
__MZMs for coherent communication systems (QAM)
__Optical add/drop filters

**Photodetectors and Solar Cells**

__Quantum-well infrared photodetectors (QWIPs)
__Type-II antimony-based photodetectors
__High speed (beyond 40 Gb/s) photodetectors
__Quantum-well and quantum-dot solar cells

**Passive Components**

__Polarization rotators for integrated photonics: reciprocal
__Polarization rotators for integrated photonics: non-reciprocal
__Integrated photonic splitters and combiners

__Arrayed waveguide gratings for DWDM applications

**Optical Networks**

__ DWDM optical networks
__ Optical wavelength converters
__ Slow light devices and optical buffers (semiconductor based)

**Integrated Photonics and Optoelectronic Devices**

__Integrated DFB laser-electroabsorption modulators
__Integrated photonics in compound semiconductors
__Silicon photonics

**Emerging Areas**

__Optoelectonic applications of 2D materials
__Wide-bandgap materials and devices beyond GaN

**Examples of possible computational projects:**

- Simulation of distributed Bragg mirrors.
- Numerical solution of asymmetric dielectric slab waveguide
- Beam Propagation Method (BPM) for analysis of integrated optics components (e.g., couplers, splitters)
- Laser solver based on rate equations and a simple scalar optical solver
- 2D (or even 3D) simulation of laser pulse interaction with various systems (a nanoparticle, a distribution of nanoparticles, a photonic crystal or more general metamaterial, etc.)
- FDTD analysis of integrated optics components (e.g., couplers, splitters)
- EM analysis of an edge-emitting laser structure to predict the shape of the near-field light spot
- General calculation of far-field distribution from near field distribution on the facet of a laser
- Simulation of optical sources and their patterns
- Simulation of optical amplifiers
- Simulation of soliton propagation

Examples of actual projects presented by students in the class in the recent past (Type “1)” projects)

- Black Phosphorous for 2D Ultrafast Pulse Lasers
- Optical Add-Drop Filters
- “Green gap ” in GaN LEDs challenges and solutions
- Physics and Applications of 2D
- Materials in Microcavity Lasers
- High-Speed Photodiode Review and Efficient Light Coupling of 850 nm PIN Photodetector for Beyond 50 Gb/s Optical Links
- Foreign-metal Seeded III-V Nanowire Synthesis
- Silicon Photonics & Hybrid Silicon Laser: A Promising Integration of Laser on Silicon
- High Speed Waveguide Modulators
- MOCVD Growth of Nanowires using Selective Area Epitaxy
- Silicon Photonics – Nonlinearity in Silicon for Advanced Silicon Photonic Applications
- Optoelectronic Applications of 2D Materials: Graphene
- Microcavity Lasers
- A Comprehensive Study on Efficiency Droop of LEDs and Possible Solutions
- Gallium Oxide Solar Blind Photodetectors
- Photonic properties of perovskite quantum dots
- Efficient Coupling of Nano-Diamond to Optical Waveguides
- Sub-picosecond Semiconductor Lasers

- High Speed VCSELs
- In situ Optical Metrology
- Non-volatile Optoelectronic Memory
- Numerical solution of the coupled Schrödinger-Poisson equations
- Neuromorphic Photonic Integrated Circuit
- Integrated Brillouin Laser
- Quantum Cascade Lasers
- Quantum Dot Solar Cells
- Soliton Propagation in Graphene-Si Ridge waveguide
- Building Optical Neural Network with Integrated Photonics

**Guidelines for the final project paper**

Here are some suggested guidelines for the final paper, as a follow up to the several discussions we have had during class.

1) **Size:** the recommended size and format of the paper is the equivalent of a letter submitted to a Journal. This could be from three to a maximum of four pages in print, with reference to the format of a letter published on IEEE Electron Device Letters or Applied Physics Letters, for instance. For students familiar with a Journal templates it is good to use such a format, but it is by no means mandatory. A plain college paper format is equally acceptable. This could be roughly ten to twelve pages double spaced. For those of you who have taken the PhD qualifying exam, the format of the document required for that could be a useful guideline.

2) **Content:** The paper should have the following items/sections
    - **Title**
    - **Name of the student & UIN ( + Your laboratory affiliation optional)**
    - **Abstract**
    - **Introduction**
    - **Several sections as needed to expand on the chosen topic of study**
    - **Conclusions**
    - **List of relevant references**

    There is the expectations that some figures will be included. These may be taken from publications or online resources as appropriate but please, always provide provenance information in the caption. Roughly, the space allocated to figures should not exceed 1/3 of the total paper length.

    Generally, you should be careful not to "lift" significant portions of verbiage from the existing literature, but to use your own words. If you feel that it is necessary to include some *verbatim* paragraphs taken from the sources you consult, you should put them in quotes and provide the reference. Always use good judgment and common sense.

    In any section of the paper and particularly in the Conclusions, your own personal impressions and opinions/outlook on the topic are welcome. Make an effort to express such personal comments, if you provide them, in a professional manner and not in a casual one. This writing assignment is meant to be "practice" toward your professional development. In this vein, make also an effort to be neat (easier if you use a template) and to be careful with grammar/spelling to put the reader in a good mood.

3) **Timeline:** Ideally, the paper should be due on the day of the exam but it is acceptable if it is submitted no later than the end of finals week (5:00pm on Friday, May 14). In case you expect a further delay, then you should advise me by email explaining briefly your circumstances. For a delay beyond the deadline for grade submission, then I could assign an incomplete grade, until your paper is submitted, but we need to have a conversation since this should not be considered an automatic default option. Nonetheless, I always stress that while deadlines are important, I am more interested in you learning so I would rather receive a late paper than none at all.