TO: The Faculty of the College of Engineering

FROM: School of Electrical and Computer Engineering of the College of Engineering

RE: New Graduate Course, ECE 60421 Nanophotonics and Metamaterials

The faculty of the School of Electrical and Computer Engineering has approved the following new course. This action is now submitted to the Engineering Faculty with a recommendation for approval.

ECE 60421 Nanophotonics and Metamaterials

Sem. 1, Lecture 3, Cr. 3.

Prerequisite by Topic: Basic knowledge of electromagnetism and solid state materials, Maxwell equations and band structure of solids

Description: The course will cover nanoscale processes and devices and their applications for manipulating light on the nanoscale. The following topics will be covered:

- Fundamentals, Maxwell's equations, light-matter interaction, dispersion, EM properties of nanostructures
- Photonic crystals and photonic crystal fibers
- Photonic and plasmonic nanocircuits
- Silicon nanophotonics
- Metal optics
- Manipulating light with plasmonic nanostructures
- Plasmonic nano-sensors
- Near-field optics
- Metamaterials: artificial magnetism and negative refractive index
- Metamaterials: superlens and hyperlens
- Transformation optics and cloaking
- Nanolasers
- Tunable and active plasmonic materials
- Refractory plasmonics
- Plasmonics for energy conversion, data storage and biomed applications
- Metasurfaces
- Intro to quantum photonics

Approved for the faculty of the Schools
of Engineering by the Engineering
Curriculum Committee
ECC Minutes #8 Date 12/13/16
Chairman ECC [signature]

Reason: This course is an essential and important addition to the permanent graduate courses flow for Fields and Optics area of ECE that uniquely provides a comprehensive overview of the most recent developments in the field of photonics. With the current rapid development of sciences and technologies, there is an urgent need to expose graduate students to the most recent advancements in research in a multidisciplinary environment. This cannot be achieved by studying any of the existing textbooks. This course addresses the existing lagging of the textbooks behind the real science and technology development and brings current state-of-the-art research into classrooms. The course cuts across several research directions and uniquely brings aspects of materials engineering, computation and quantum physics into the most current and dynamic areas of optics. This course is a necessary addition to the existing FO course flow and is nicely aligned with both 604 and 695 courses offered by professors Weiner (ultra-fast optics), Bermel (photonics for energy), Narimanov (theoretical EMs), Jacob (quantum photonics) as well as Physics course by Professors Chen, Li and others. This course is also aligned with undergraduate FO courses including 30412 and 30414. In addition to serving FO area and providing the necessary training for future optical engineers, his course provides a great opportunity for other areas' (such as MN) students to get up to speed with current photonic concepts and technologies, which is a necessary knowledge for upcoming engineers in various fields including nanoelectronics, IT, and materials.

Michael R Melloch

Michael R. Melloch, Associate Head
School of Electrical and Computer Engineering

Office of the Registrar
FORM 40G REV. 4/13

PURDUE UNIVERSITY
REQUEST FOR ADDITION, EXPIRATION, OR REVISION OF A GRADUATE COURSE (50000-60000 LEVEL)

DEPARTMENT: Electrical and Computer Engineering
EFFECTIVE SESSION: Spring 2017

INSTRUCTIONS: Please check the items below which describe the purpose of this request.

- [x] 1. New course with supporting documents (complete proposal form)
- [ ] 2. Add existing course offered at another campus
- [ ] 3. Expiration of a course
- [ ] 4. Change in course number
- [ ] 5. Change in course title
- [ ] 6. Change in course credit/type
- [ ] 7. Change in course attributes
- [ ] 8. Change in instructional hours
- [ ] 9. Change in course description
- [ ] 10. Change in course requisites
- [ ] 11. Change in semesters offered
- [ ] 12. Transfer from one department to another

PROPOSED:
Subject Abbreviation: ECE
Course Number: 60421
Long Title: Nanophotonics and Metamaterials
Short Title: Nanophotonics & Metamaterials
Abbreviated title will be entered by the Office of the Registrar if omitted. (30 CHARACTERS ONLY)

EXISTING:
Subject Abbreviation:
Course Number:

TERMS OFFERED Check All That Apply:
- [x] Fall
- [ ] Spring
- [ ] Summer

CAMPUS(ES) INVOLVED
- [ ] Calumet
- [ ] Cont Ed
- [ ] Ft. Wayne
- [ ] Indianapolis
- [ ] N. Central
- [ ] Tech Statewide
- [x] W. Lafayette

CREDIT TYPE
1. Fixed Credit: Cr. Hrs. 3
2. Variable Credit Range:
   Minimum Cr. Hrs
   (Check One) To [ ] Or [ ]
   Maximum Cr. Hrs
3. Equivalent Credit: Yes [ ] No [x]
4. Thesis Credit: Yes [ ] No [x]

COURSE ATTRIBUTES: Check All That Apply
1. Pass/Not Pass Only [ ]
2. Satisfactory/Unsatisfactory Only [ ]
3. Repeatable [ ]
   Maximum Repeatable Credit: [ ]
4. Credit by Examination [ ]
5. Fees [ ] Coop [ ] Lab [ ] Rate Request
   Include comment to explain fee
6. Registration Approval Type
   Department [ ] Instructor [ ]
7. Variable Title [ ]
8. Honors [ ]
9. Full Time Privilege [ ]
10. Off Campus Experience [ ]

Schedule Type	Minutes Per Mtg	Meetings Per Week	Weeks Offered	% of Credit Allocated
Lecture	50	3	16	100
Recitation				
Presentation				
Laboratory				
Lab Prep				
Studio				
Distance				
Clinic				
Experiential				
Research				
Ind. Study				
Pract/Observ				

Cross-Listed Courses

COURSE DESCRIPTION (INCLUDE REQUISITES/RESTRICTIONS):

The course will cover nanoscale processes and devices and their applications for manipulating light on the nanoscale. The following topics will be covered:
- Fundamentals, Maxwell's equations, light-matter interaction, dispersion, EM properties of nanostructures
- Photonic crystals and photonic crystal fibers

*COURSE LEARNING OUTCOMES:

i. to derive, calculate and analyze the optical properties of metals including plasma frequency, relaxation time, dielectric constant, reflection and transmission coefficients; (a)
ii. to derive and analyze the optical properties of nanophotonic systems including color centers in solids, metallic nanoparticles, metal-dielectric

Calumet Department Head	Date	Calumet School Dean	Date	Calumet Director of Graduate Studies	Date
Fort Wayne Department Head	Date	Fort Wayne School Dean	Date	Fort Wayne Director of Graduate Studies	Date
Indianapolis Department Head	Date	Indianapolis School Dean	Date	IUPUI Associate Dean for Graduate Education	Date
North Central Department Head	Date	North Central School Dean	Date	North Central Director of Graduate Studies	Date
[signature] West Lafayette Department Head	10/7/16 Date	[signature] West Lafayette College/School Dean	12/14/16 Date	Date Approved by Graduate Council	Date
Graduate Area Committee Convener	Date	Graduate Dean	Date	Graduate Council Secretary	Date
				West Lafayette Registrar	Date

OFFICE OF THE REGISTRAR

Supporting Document to the Form 40G
for a New Graduate Course

To: Purdue University Graduate Council

From: Faculty Member: Vladimir Shalaev

Department: Electrical and Computer Engineering

Campus: West Lafayette

Date:

Subject: Proposal for New Graduate Course

Contact for information if questions arise:

Name: Matt Golden
Phone: 494-3374
Email: goldenm@purdue.edu
Address: EE Building, Room 135

Course Subject Abbreviation and Number: ECE 60421
Course Title: Nanophotonics and Metamaterials

Course Description:
The course will cover nanoscale processes and devices and their applications for manipulating light on the nanoscale. The following topics will be covered:

- Fundamentals, Maxwell's equations, light-matter interaction, dispersion, EM properties of nanostructures
- Photonic crystals and photonic crystal fibers
- Photonic and plasmonic nanocircuits
- Silicon nanophotonics
- Metal optics
- Manipulating light with plasmonic nanostructures
- Plasmonic nano-sensors
- Near-field optics
- Metamaterials: artificial magnetism and negative refractive index
- Metamaterials: superlens and hyperlens
- Transformation optics and cloaking
- Nanolasers
- Tunable and active plasmonic materials
- Refractory plasmonics
- Plasmonics for energy conversion, data storage and biomed applications

- Metasurfaces
- Intro to quantum photonics

Semesters Offered:

For the benefit of graduate student plan of study development, how frequently will this prototype be offered? Which semesters?

Each Fall of odd years

A. Justification for the Course:

Provide a complete and detailed explanation of the need for the course (e. g., in the preparation of students, in providing new knowledge/training in one or more topics, in meeting degree requirements, etc.), how the course contributes to existing majors and/or concentrations, and how the course relates to other graduate courses offered by the department, other departments, or interdisciplinary programs.

This course is an essential and important addition to the permanent graduate courses flow for Fields and Optics area of ECE that uniquely provides a comprehensive overview of the most recent developments in the field of photonics. With the current rapid development of sciences and technologies, there is an urgent need to expose graduate students to the most recent advancements in research in a multidisciplinary environment. This cannot be achieved by studying any of the existing textbooks. This course addresses the existing lagging of the textbooks behind the real science and technology development and brings current state-of-the-art research into classrooms. The course cuts across several research directions and uniquely brings aspects of materials engineering, computation and quantum physics into the most current and dynamic areas of optics. This course is a necessary addition to the existing FO course flow and is nicely aligned with both 604 and 695 courses offered by professors Weiner (ultra-fast optics), Bermel (photonics for energy), Narimanov (theoretical EMs), Jacob (quantum photonics) as well as Physics course by Professors Chen, Li and others. This course is also aligned with undergraduate FO courses including 30412 and 30414. In addition to serving FO area and providing the necessary training for future optical engineers, his course provides a great opportunity for other areas' (such as MN) students to get up to speed with current photonic concepts and technologies, which is a necessary knowledge for upcoming engineers in various fields including nanoelectronics, IT, and materials.

Justify the level of the proposed graduate course (500- or 600-level) including statements on, but not limited to: (1) the target audience, including the anticipated number of undergraduate and graduate students who will enroll in the course; and (2) the rigor of the course.

The proposed course is at the graduate level (600-level) because it targets students that are ready or already doing research. The course enrollment was very stable over all the past offerings and is about 20. The prerequisites of the course are also at the graduate level including knowledge of electromagnetism and solid state materials. It contains advanced concepts that cut across solid states physics, mathematics, theoretical physics, material science, nanotechnology, nanofabrication, energy so it is more appropriate for graduate students. It also uses advanced course materials such as technical research papers.

Use the following criteria:
Graduate Council policy requires that courses at the 50000 level in the Purdue system should be taught at the graduate level and meet four criteria: a) the use of primary literature in conjunction with advanced secondary sources (i.e., advanced textbooks); b) assessments that demonstrate synthesis of concepts and ideas by students; c) demonstrations that topics are current, and; d) components that emphasize research approaches/methods or discovery efforts in the course content area (reading the research, critiquing articles, proposing research, performing research). Such courses should be taught so that undergraduate students are expected to rise to the level of graduate work and be assessed in the same manner as the graduate students.

- Anticipated enrollment
  - Undergraduate 0
  - Graduate 20

B. Learning Outcomes and Method of Evaluation or Assessment:

ECE Graduate Learning Outcomes:

a. Knowledge and Scholarship (thesis/non-thesis)
b. Communication (thesis/non-thesis)
c. Critical Thinking (thesis/non-thesis)
d. Ethical and Responsible Research (thesis) or Professional and Ethical Responsibility (non-thesis)

- List Learning Objectives for this course and map each Learning Objective to one or more of the ECE Learning Outcomes (a-d, listed above):

A student who successfully fulfills the course requirements will demonstrate the following abilities:

i. to derive, calculate and analyze the optical properties of metals including plasma frequency, relaxation time, dielectric constant, reflection and transmission coefficients; (a)

ii. to derive and analyze the optical properties of nanophotonic systems including color centers in solids, metallic nanoparticles, metal-dielectric slabs, thin metal films, metamaterial slabs with negative refraction; (a)
iii. to analyze surface plasmon polariton waveguides and waveguide properties; (a,c)
iv. to articulate the fundamentals of optics of structured media; and (b)
v. to demonstrate an understanding of novel concepts in photonics, including photonic crystals, metamaterials, nanoscale interconnects, metal optics, transformation optics, nanolasers, nanosensors, super- and hyperlens and quantum nanophotonics. (b,c)

The students will have multiple opportunities to satisfy these ABET outcomes. The primary means will be through homeworks, mid-term exam, class participation, and final report. The instructor will write questions based on these Course Outcomes.

- Methods of Instruction
    - Lecture
- Will/can this course be offered via Distance Learning?
- Grading Criteria

Grading criteria (select from checklist); include a statement describing the criteria that will be used to assess students and how the final grade will be determined. Add and delete rows as needed.

- mid-term exam
- final report
- homework
- attendance/participation

► Describe the criteria that will be used to assess students and how the final grade will be determined:

The course will be graded primarily on a combination of mid-term, homeworks and final report. A smaller part of the grade will be based on class participation.

C. Prerequisite(s):

List prerequisites and/or experiences/background required. If no prerequisites are indicated, provide an explanation for their absence. Add bullets as needed.

- Prerequisite by Topic: Basic knowledge of electromagnetism and solid state materials, Maxwell equations and band structure of solids

D. Course Instructor(s):

Provide the name, rank, and department/program affiliation of the instructor(s). Is the instructor currently a member of the Graduate Faculty? (If the answer is no, indicate when it is expected that a request will be submitted.) Add rows as needed.

Name	Rank	Dept.	Graduate Faculty or expected date
Vladimir Shalaev	Professor	ECEN	Yes

E. Course Outline:

Provide an outline of topics to be covered and indicate the relative amount of time or emphasis devoted to each topic. If laboratory of field experiences are used to supplement a lecture course, explain the value of the experience(s) to enhance the quality of the course and student learning. For special topics courses, include a sample outline of a course that would be offered under the proposed course. **(This information must be listed and may be copied from syllabus).**

- Fundamentals, Maxwell's equations, light-matter interaction, dispersion, EM properties of nanostructures, etc. – 2 lectures
- Photonic crystals and photonic crystal fibers – 4 lectures
- Photonic and plasmonic nanocircuits – 2 lectures
- Silicon nanophotonics - 1 lecture
- Metal optics – 2 lectures
- Manipulating light with plasmonic nanostructures – 2 lectures
- Plasmonic nano-sensors – 1 lecture
- Near-field optics – 1 lecture
- Metamaterials: artificial magnetism and negative refractive index – 2 lectures
- Metamaterials: superlens and hyperlens – 1 lecture
- Transformation optics and cloaking – 2 lectures
- Nanolasers – 1 lecture
- Tunable and active plasmonic materials – 1 lecture
- Refractory plasmonics – 1 lecture
- Plasmonics for energy conversion, data storage and biomed applications – 2 lectures
- Metasurfaces – 3 lectures
  Intro to quantum photonics – 2 lectures

F. Reading List (including course text):

A primary reading list or bibliography should be limited to material the students will be required to read in order to successfully complete the course. It should not be a compilation of general reference material.

A secondary reading list or bibliography should include material students may use as background information.

- Primary Reading List

- Secondary Reading List

- Fundamentals, Maxwell's equations, light-matter interaction, dispersion etc….
- [1] *"Optics,"* Hecht (Addison Wesley , 1990)
- [2] *"Fundamentals of Photonics,"* B.E.A. Saleh, M.C. Teich (John Wiley& Sons, 1991)
- [3] "Classical Electrodynamics" J. D. Jackson (John Willey & Sons, 1999)
- ● Photonic Crystals
- [1] *"Photonic Crystals: Molding the Flow of Light ,"* J. D. Joannopoulos, R. D. Meade, J. N. Winn (Princeton University Press, 1995)
- [2] *"Roadmap on Photonic Crystals,"* Editors: S. Noda and T. Baba (Kluwer Academic Publishers, 2003)
- ● Metal optics, surface plasmon polaritons, near-field optics:
- [1] *"Near-field optics and surface plasmon polaritons,"* Edited by: Satoshi Kawata (2001) Available from the course webpage
- [2] *"Surface plasmons on smooth and rough surfaces and on gratings,"* Raether (Springer-Verlag, New York, 1986)…out of print…but I'll provide notes
- [3] Stefan Mayer, "Plasmonics." Cambridge Press (2007)

G. Library Resources

Describe any library resources that are currently available or the resources needed to support this proposed course.

H. Course Syllabus

(While not a necessary component of this supporting document, an example of a course syllabus is available, for information, by clicking on the link below, which goes to the *Graduate School's Policies and Procedures Manual for Administering Graduate Student Program.*
See Appendix K.
http://www.purdue.edu/gradschool/faculty/documents/Graduate_School_Policies_and_Procedures_Manual.pdf