SEMINAR IN PHYSICS

Friday, April 6, 2018
3:30-4:25 – Ross 0220

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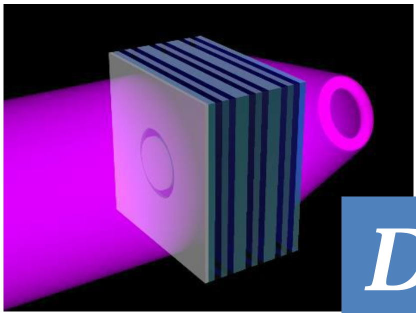

Dr. Henri J. Lezec

Project Leader, CNST Nanofabrication Research Group
National Institute of Standards and Technology

Plasmonic Metamaterials and Lasers at Visible and Ultraviolet Frequencies

Renowned physics researcher Dr. Henri J. Lezec of the National Institute of Standards and Technology will present a seminar on artificial metamaterials and their interaction with light in nanoscale structure. Dr. Lezec is currently leading a project to develop negative-index metamaterials at visible frequencies by using advanced nanofabrication techniques with focused ion beams to implement bulk metamaterials operating at visible and ultra-violet wavelengths.

These structures will lead to a wide range of potential applications including high-contrast nanoparticle optical sensors working in the visible, to the first implementation of a Veselago flat lens functioning in the near ultraviolet.

Dr. Lezec is a prolific writer of important publications and a sought-after invited speaker. He has published over 100 papers, including three letters in Nature and four in Science, as well as four in Physical Review Letters and six in Nano Letters. His work has been recognized with a fellowship in the Optical Society of America in 2010, and with the award of the prestigious Julius Springer Prize for Applied Physics in 2011.

[More information on Dr. Lezec]

Plasmonic Metamaterials and Lasers at Visible and Ultraviolet Frequencies

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Artificial metamaterials – metallo-dielectric composites tailored on deep-subwavelength scale – enable implementation of electromagnetic responses not found in nature, leading to potentially useful applications as well as yielding new insights into the fundamental nature of light. Here we use advanced nanofabrication techniques, such as ion-beam-assisted sputter deposition and focused-ion-beam (FIB) milling, to implement bulk metamaterials operating at visible and ultra-violet wavelengths and having refractive indices ranging from highly anisotropic and positive [1] to quasi-isotropic and negative [2]. These structures exploit ultra-smooth stacks of metal and dielectric layers sustaining surface-plasmon polaritons (SPPs), electromagnetic modes which propagate along metal surfaces with evanescent confinement. Exploiting these structures to tailor the flow of light in exotic ways, we realize devices ranging from high-contrast, near-field nanoparticle optical sensors working in the visible, to the first implementation of a Veselago flat lens [3] functioning in the near ultraviolet. In addition to their novel refractive properties, we demonstrate that metamaterials can display surprising opto-mechanical responses, in particular under the form of a negative radiation-pressure response to plane-wave illumination.

Recent years have witnessed a growing interest in the development of small-footprint lasers for potential applications in small-volume sensing and on-chip optical communications. Once again, we turn to surface plasmon polaritons, demonstrating how they offer an effective route to achieving lasing at nanometer-scale dimensions when resonantly amplified in contact with a gain medium. By confining SPPs to an open Fabry-Perot cavity formed by a flat metal surface coated with a subwavelength-thick layer of optically pumped gain medium and orthogonally bound by a pair of flat metal sidewalls, we achieve narrow-linewidth visible-frequency lasing at room temperature [4]. We show how the lasing threshold and linewidth can be lowered by incorporating a FIB-patterned low-profile tapered grating on the cavity floor to couple the excitation beam into an orthogonally propagating pump SPP which strong modal overlap with the gain medium. Low-perturbation transmission-configuration sampling of the lasing plasmon mode is achieved via an evanescently coupled recessed nanoslit, opening the way to high–figure of merit refractive index sensing of analytes interacting with the open metallic trench.

[1] T. Xu and H. J. Lezec, *Nat. Comm*. Vol. 5, 4141 (2014). [2] T. Xu, A. Agrawal, M. Abashin, K. J. Chau, and H. J. Lezec, *Nature* Vol. 497, 470 (2013). [3] V. G. Veselago, Sov. Phys. Usp. Vol. 10, 509 (1968). [4] W. Zhu, T. Xu, W. Wang, C. Zhang, P. B. Deotare, A. Agrawal, and H. J. Lezec, *Science Advances*, Vol. 3, e1700909, (2017).