Short course on

Nonlinear Photonic Crystals and their applications for Optical Signal Processing

Introduction: Very recently, IBM advertised their new technology, called “silicon nanophotonics”, where optical and electrical signal will coexist on a single silicon die. That is only the latest of a series of impressive breakthroughs which have revolutionized photonics in the last decade. Photonic crystal is a particular photonic nanotechnology which has much progressed in the last years and which is likely to fit in this scheme. Photonic crystals bring specific functionalities, related to the enhancement of the light-matter interaction and the control of the dispersion which are very specific and valuable. We will briefly discuss photonic crystals and how they relate to the emerging field of nanophotonics for signal processing.

Venue: **MAS Executive Classroom 1** (SPMS-MAS-03-06)
Host: Asst. Prof. Cesare Soci

29 January 2013, Tuesday	
Signal processing using nanophotonics – **Alfredo De Rossi**	14:00 – 15:00
A photonic crystal platform in diamond for applications to linear and nonlinear optics – **Xavier Checoury**	15:00 – 16:00

31 January 2013, Thursday	
Nonlinear photodetector and self-pulsing oscillations in silicon photonic crystals – **Xavier Checoury**	11:00 – 12:00
Enhanced nonlinear effects in photonic crystals: optical transistors, memories and waveguides – **Alfredo De Rossi**	12:00 – 13:00

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29th January 2013

Signal processing using nanophotonics – Alfredo De Rossi

I will first explain why optics is used for signal processing and give some examples of the current trends. I will then consider a more specific class of techniques entailing nonlinear optics. I will explain what the limitations of the current approach to nonlinear optics are and why nanophotonics is promising. I will focus on a specific nanophotonic technology, namely the photonic crystals (PhCs). The main properties of PhC will be introduced and I will also explain how they are fabricated.

A photonic crystal platform in diamond for applications to linear and non-linear optics – Xavier Checoury

After a short introduction to PhCs and PhC cavities, I will describe some of the properties of diamond that make it an attractive material for photonics and nonlinear optics. Then, I will show how we developed a platform for diamond photonics with PhC waveguides and cavities. As an example of application of these cavities, I will show how we recently used them to do a simple linear detection of a refractive index change near the surface of the diamond confirming that diamond PhC cavities can be used for the realization of optical biosensors.

31st January 2013

Nonlinear photodetector and self-pulsing oscillations in silicon photonic crystal cavities – Xavier Checoury

When increasing light matter interaction in a silicon nanocavity, for example to generate four wave mixing or enhanced Raman scattering, the studied effect is always accompanied by two-photon absorption, a detrimental effect that occurs under high power conditions. Here, I will show how we succeeded in making this absorption useful. The first application consists in using two-photon absorption to make a sensitive photodetector in silicon that works at 1.5 µm, i.e. at a frequency where silicon is transparent at low power. Next, I will show how the balance between the nonlinear response and the photon cavity lifetime could trigger self-pulsing at frequencies that can theoretically reach 50 GHz in silicon PhC cavities. This generation of micro-wave signal on an optical carrier may have applications for microwave photonics that aims to provide functions that are complex to obtain in the radio-frequency domain.

Enhanced nonlinear effects in photonic crystals: optical transistors, memories and waveguides – Alfredo De Rossi

I will discuss two kind of nonlinear devices based on PhC, based on enhanced nonlinear effects. The first, is an optical nanocavity, which can be used to control the transmission of an optical signal using another optical signal. It can be viewed as the optical analogue of the transistor. I'll also show how an “optical memory” could be based on that. The second class of devices is a waveguide, also based on PhCs. These waveguides can be designed to shape the dispersion almost in an arbitrary way and provide the functionalities of about 100 m of standard single mode fiber. This promises the integration on a photonic chip of many optical processing techniques.

Speaker Biographies

Alfredo De Rossi graduated at University of Rome, Italy, in 1997 and received his PhD at Rome University in 2002 on nonlinear optics in semiconductor chips. He is with Thales Research and Technology (Thales Corporate Research Laboratory) since 2000. He has been working in nonlinear optics, semiconductor photonic devices, infrared detectors and lasers. Present focus of his research is on photonic crystals for all-optical processing.

Xavier Checoury received the engineering degree from the École Nationale Supérieure des Télécommunications (ENST), Paris, and the M.S. Degree from University Pierre et Marie Curie, Paris VI, both in 1998. From 1999 to 2002, he was an R&D Engineer at EADS Telecom (Paris), a subsidiary of the European Aeronautic Defence and Space company (EADS). During his PhD thesis (2002-2005) at the Institute for Fundamental Electronics (University Paris Sud), he studied photonic crystal lasers both from a theoretical and experimental point of view. Since 2006, he works at the University Paris-Sud, first as associate professor and as professor since October 2012. His research interest concerns nonlinear effects in photonic crystals, semiconductor lasers, and numerical modeling.