~~Influence of erbium concentration in Er: Y_2O_3 thin films for optical amplification~~

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~~Thanks to the development of optical fibers in the last twenty years, communication technology has known an extraordinary improvement. Nowadays an optical signal can travel along thousands of kilometers carrying a lot of information through optical glass fibers, suffering very small losses, thanks to the well-known optical window around 1.54 μm. The most common way to amplify and regenerate optical signals at this wavelength is to put strategically a small amount of erbium ions inside the glass fibers. Erbium, in fact, is characterized by a radiative atomic transition at 1.54 μm. As well as this incredible success in communication technology, in the second half of the last century there was a continuous development also in silicon microelectronics, thanks to the realization of devices more and more small, cheap and fast. In order to further increase the speed of the information through electronic chips one charming possibility is the integration of photonic devices on a silicon substrate, so that it would be possible to use light as vehicle of information. One of the main limits in this sense is represented by the lacking of efficient planar amplifiers fully developed on silicon platforms. Our goal is the realization of an amplifier based on Er-doped systems in order to obtain all the advantages reached with the optical fiber technology. Unfortunately, the integration of these systems into silicon chips needs a strong reduction of the size: for this reason an acceptable gain can be obtained only with a great amount of Er concentration. An interesting material for this kind of application seems to be yttrium oxide, because it is compatible with silicon (because of his lattice parameter) and can be easily doped with large quantities of erbium (because of the similarities of these two atoms). Erbium doped yttrium oxide thin films have been synthesized by using UHV RF magnetron sputtering. These films have been grown by co-sputtering from Y_2O_3 and Er_2O_3 targets. By varying the power applied to the latter target, a very huge range of erbium concentration has been investigated (between 0.2 at.% and 14.3 at.%). In all this range structural properties of yttria host have been studied in detail, demonstrating that they not depend on the Er content, because of the structural similarities between yttrium and erbium oxides. It has been observed that all of the as deposited films show PL emission at 1.54 μm and particularly the maximum PL intensity has been found for the films containing 3.3 at.% of Er. This concentration (corresponding to 2.45×10^{21} Er/cm$_3$) is the best compromise between the amount of optically active ions and the lifetime. In fact higher Er concentrations lead to a reduction of PL intensity, due to a strong reduction of the lifetime, which has been fully explained by concentration quenching effects. It has been demonstrated the existence of two different regimes: the first one concerns erbium amount up to 9 at.%, where each Er atom is bonded only to Y and O atoms in the second shell; the second one starts for higher Er contents, where Er-O-Er bonds necessarily exist. The spectroscopic properties of the films belonging to both these two regimes have been investigated and compared. For low Er contents (for example 1.1 at.%), it has been demonstrated that the excited Er ions mainly populate the first two excited states, because of the low phononic decay rates of the yttria host; besides emission of visible light has been attributed to upconverting phenomena. A higher number of Er ions instead (for example 11.4 at.%) causes an increase of the phononic decay rates with respect to the radiative ones. As a consequence in this case upconverting effects are less detrimental for the PL emission at 1.54 μm. Therefore the Y_2O_3 film with 11.4 at.% of Er is considered the most promising for the achievement of optical gain at 1.54 mm.~~

835

Integration of a Fiber-To-The-Home Transceiver on a Silicon Nanophotonics platform

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We discuss the advancements in realizing a fully integrated Fiber-To-The-Home transceiver on a Silicon-On-Insulator (SOI) platform. Special attention will be given to solving the fiber/chip coupling problem with a grating duplexer.

Introduction: Current broadband services such as copper-based access technologies, i.e., the asymmetrical digital subscriber line (ADSL) and cable modem (CM), have reached there limits and the growing demand for bandwidth is driving the deployment of optical networks. Without a doubt, Fiber-To-

The-Home is the most impressive technology for realizing very high symmetrical bandwidths. Due to the rising demand, optical fibers become cheaper every year and many advances have made optical fiber networks much less costly than they once were. Still, the use of discrete optical components for fabricating FTTH transceivers makes these devices not suitable for mass production. The key to solve this problem is integrating the optical functionalities on a single chip. Through integration of FTTH transceivers it is possible to significantly reduce the installation costs of FTTH optical networks. Furthermore the maintenance cost en power consumption will decrease. It is believed that integrated optical equipment will stimulate in the near future the deployment of FTTH networks. [1]

Point-to-point Fiber-to-the-Home optical access networks require large volume and low-cost optical transceivers, both at the subscriber and the central office side. From the perspective of the transceiver at the subscriber side, 1310nm is the upstream channel and 1490nm and 1550nm are the downstream channels for data and CATV. In Figure 1, an integrated FTTH transceiver is schematic illustrated. Starting from the fiber, we can distinguish five functionalities: 1. Interface between the fiber and the optical chip; 2. Splitting of the downstream and upstream channels; 3. Splitting of the downstream wavelengths (CATV and data); 4. Detection of the downstream wavelengths; 5. Transmission of the upstream wavelength.

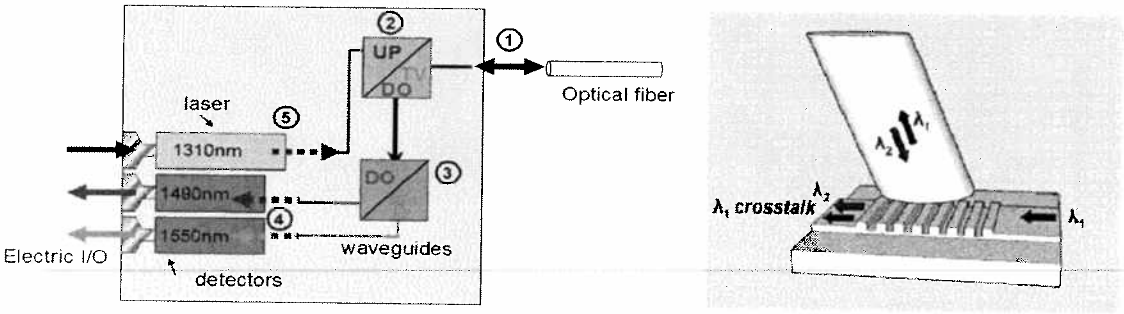

Figure 1: (left) Schematic overview of an integrated FTTH transceiver (right) Operation principle of a grating duplexer.

Silicon-on-insulator technology has many advantages for the realization of photonic integrated circuits. First of all the platform is CMOS-compatible and due to the high refractive index contrast, the designs are very compact. Furthermore, out-of-plane coupling can be realized by the use of a diffractive grating [2]. This makes wafer scale testing feasible. By unifying these advantages it is possible to fabricate nanophotonic integrated circuits in large volumes at a low cost.

In order to couple and at the same time split the upstream and downstream wavelength bands, we use a 1-dimensional grating duplexer [3]. The working principle is shown in Figure 2. Under a certain angle of the optical fiber, the Bragg condition is fulfilled for both wavelengths λ1 and λ2 and the 2 wavelength bands will couple in opposite directions. The coupling efficiencies, see Figure 3, of the central wavelengths are -6dB for 1300 nm and -4dB for 1520 nm. At the communication wavelengths 1310nm, 1490nm and 1550nm the coupling efficiencies are respectively -7dB, -6dB and -8dB.

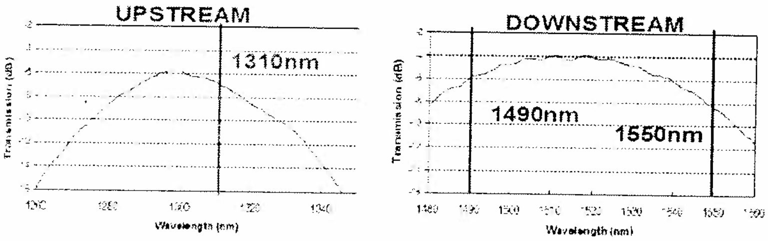

Figure 2: Transmission spectrum of the grating duplexer for the upstream band (left graph) and the downstream band (right graph).

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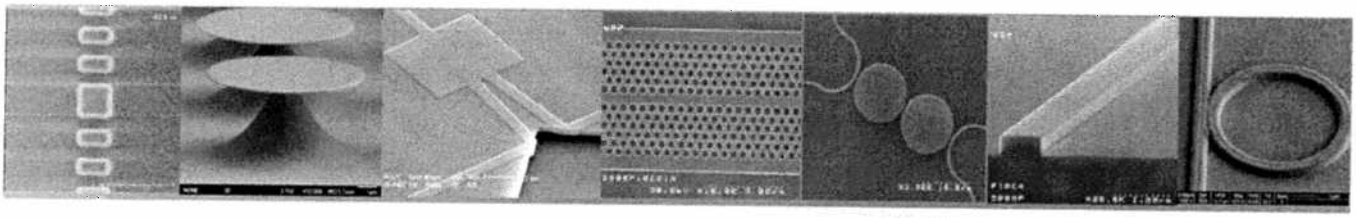

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Introduction

In its everlasting quest to deliver more data using smaller and lower cost components, the silicon industry is moving full steam ahead towards its final frontiers of size, device integration and complexity. For several years, **silicon-based photonic devices** have been widely considered to develop integrated circuits to overcome the microelectronic bottlenecks by combining existing silicon infrastructure with optical communications technology, and a merger of electronics and photonics into one integrated dual-functional device.
The challenge for **silicon photonics** is to manufacture low-cost information processing components by using standard and mature **CMOS technology**. Numerous photonic devices have already been developed in the last years to emit, propagate and distribute, modulate and detect light on silicon substrates. However, several obstacles should be overcome to foresee silicon photonics for the next generation high-speed systems.

The *5th Optoelectronic and Photonic Winter School* is dedicated to introduce, examine and review the recent achievements in the field covering fundamentals and devices, materials and technologies.

The School goals are:

1. to put the emphasis on the main building blocks towards a silicon photonics: from the light generation to the CMOS integration
2. to introduce PhD students and young researchers to this field and to determine the state of the art of silicon photonics, from the theory to the characterization with a point on the technology
3. to be a forum to exchange experiences about new advances and developments in the field thus promoting the scientific exchange between participants and contributors.

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