XXII RINEM

Riunione Nazionale di Elettromagnetismo

September 3-6, 2018 Cagliari, Italy

Proceedings

XXII RINEM

Cagliari, Italy **September 3-6, 2018**

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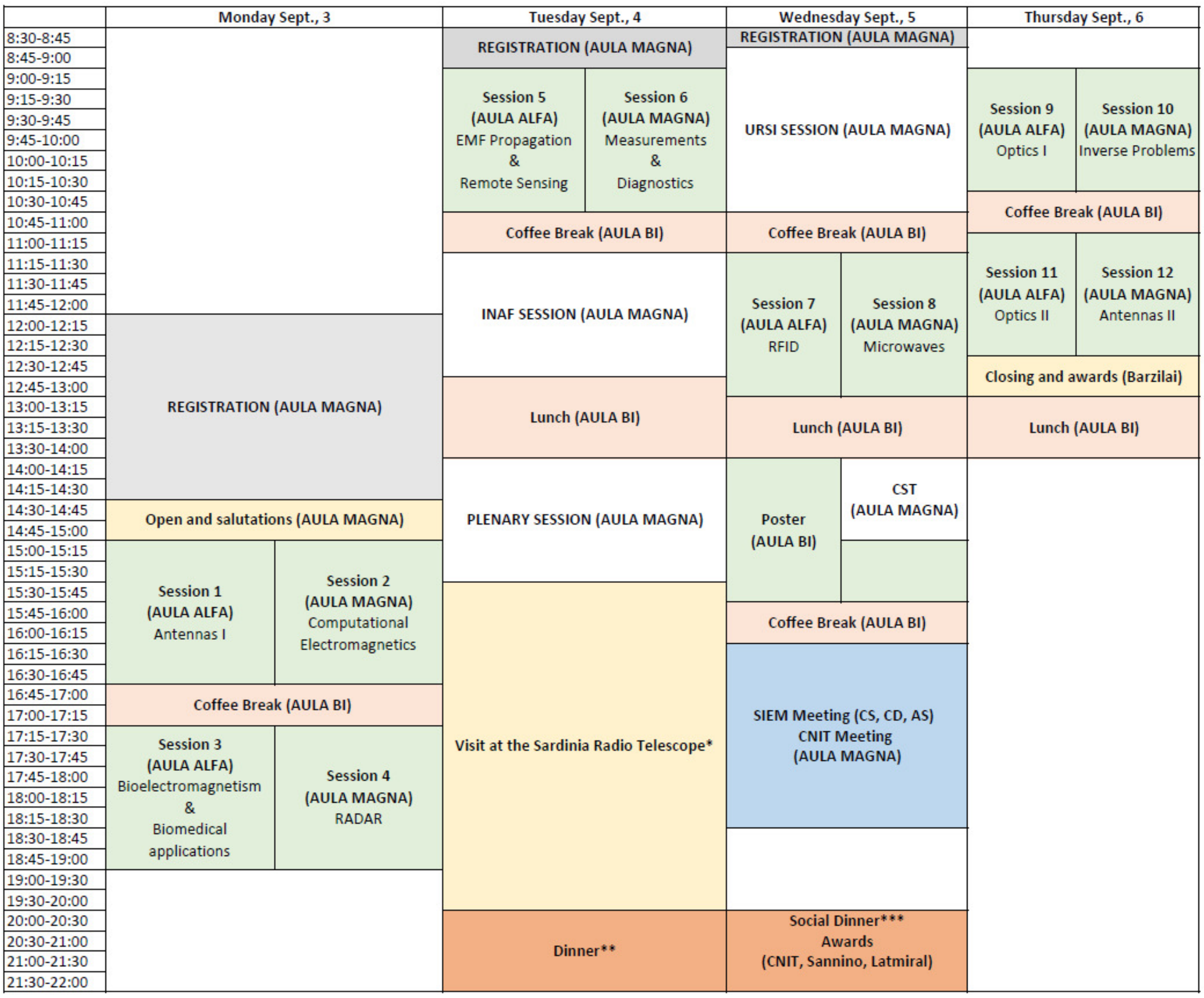
Program Overview



	Monday Sept., 3		Tuesday Sept., 4		Wednesday Sept., 5		Thursday Sept., 6	
8:30-8:45			REGISTRATION (AULA MAGNA)		REGISTRATION (AULA MAGNA)			
8:45-9:00					URSI SESSION (AULA MAGNA)			
9:00-9:15			Session 5 (AULA ALFA) EMF Propagation & Remote Sensing	Session 6 (AULA MAGNA) Measurements & Diagnostics			Session 9 (AULA ALFA) Optics I	Session 10 (AULA MAGNA) Inverse Problems
9:15-9:30								
9:30-9:45								
9:45-10:00								
10:00-10:15								
10:15-10:30								
10:30-10:45							Coffee Break (AULA BI)	
10:45-11:00			Coffee Break (AULA BI)		Coffee Break (AULA BI)			
11:00-11:15							Session 11 (AULA ALFA) Optics II	Session 12 (AULA MAGNA) Antennas II
11:15-11:30			INAF SESSION (AULA MAGNA)		Session 7 (AULA ALFA) RFID	Session 8 (AULA MAGNA) Microwaves		
11:30-11:45								
11:45-12:00								
12:00-12:15	REGISTRATION (AULA MAGNA)							
12:15-12:30								
12:30-12:45							Closing and awards (Barzilai)	
12:45-13:00			Lunch (AULA BI)					
13:00-13:15					Lunch (AULA BI)		Lunch (AULA BI)	
13:15-13:30								
13:30-14:00								
14:00-14:15			PLENARY SESSION (AULA MAGNA)		Poster (AULA BI)	CST (AULA MAGNA)		
14:15-14:30								
14:30-14:45	Open and salutations (AULA MAGNA)							
14:45-15:00								
15:00-15:15	Session 1 (AULA ALFA) Antennas I	Session 2 (AULA MAGNA) Computational Electromagnetics						
15:15-15:30								
15:30-15:45			Visit at the Sardinia Radio Telescope*					
15:45-16:00					Coffee Break (AULA BI)			
16:00-16:15								
16:15-16:30					SIEM Meeting (CS, CD, AS) CNIT Meeting (AULA MAGNA)			
16:30-16:45								
16:45-17:00	Coffee Break (AULA BI)							
17:00-17:15								
17:15-17:30	Session 3 (AULA ALFA) Bioelectromagnetism & Biomedical applications	Session 4 (AULA MAGNA) RADAR						
17:30-17:45								
17:45-18:00								
18:00-18:15								
18:15-18:30								
18:30-18:45								
18:45-19:00								
19:00-19:30								
19:30-20:00								
20:00-20:30			Dinner**		Social Dinner*** Awards (CNIT, Sannino, Latmiral)			
20:30-21:00								
21:00-21:30								
21:30-22:00								

Session 9: OPTICS I

Chairperson: Stefano Selleri

ELECTROMAGNETIC PROPAGATION FOR ON-CHIP WIRELESS COMMUNICATIONS

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Abstract

Optical Wireless Networks on-Chip are promising solutions to overcome problems of miniaturization and energy consumption in a multicore on-chip environment. In this paper, the optical wireless channel is modeled through a ray tracing approach, and the relationship between the optical antennas gain and the communication range in the on-chip propagation environment is investigated.

Index Terms – Channel Modeling, Ray Tracing, Optical Wireless Networks on Chip

I. INTRODUCTION

Parallel computation through multi-processors architectures is likely to be a point of no return to cope with the increasing request for greater computation efficiency [1]. Nevertheless, the physical interconnection of many cores currently undergoes several technological impairments, to the extent that wireless network on chip are being investigated as a promising solution [2]. In this work, on-chip wireless connections at optical frequencies are studied by means of a ray-tracing approach, and the impact of path-loss on the communication distance is investigated for different positions and radiation properties of the antennas.

II. OPTICAL WIRELESS NETWORKS ON CHIP

Although multi-processor chips are widely acknowledged as a promising solution for high-performance computing, prospects towards kilo-cores architectures might be seriously thwarted by interconnects issues, e.g. in terms of complexity, high latency and power consumption [2]. These limitations heavily affect electrical network on chip (NoC), as well as optical NoC (ONoC), although to an overall lesser extent [3]. Wireless networks on-chip (WiNoC) have therefore gained consideration [2] as an effective way to overcome the bottleneck of the physical interconnection between many cores. To overcome the difficulties in antenna integration and energy consumption that obviously rise at UWB/millimeter frequencies, optical WiNoC (OWiNoC) have been recently proposed [3], to combine the advantages of both ONoC and WiNoC. A crucial aspect of the optical link design is path-loss assessment, which is expected to be a heavy impairment at so large frequency. In spite of the tiny chip size, on-chip wireless communications at optical frequency are likely to occur in far-field conditions, e.g. up to distances by far greater than 100λ. Numerical solutions like FDTD are therefore almost impractical, whereas Ray Tracing (RT) can be relied on [4], with noticeable savings in memory and CPU time. The antenna radiation patterns are then calculated by FDTD [3], while the link can be modeled using RT.

III. Ray Tracing for OWiNoC

The on-chip wireless channel is commonly sketched as a layered structure (Fig. 1a), where a plane dielectric slab including the transmitting (TX) and the receiving (RX) antennas is bounded by two different media on the upper and on the lower side. The electromagnetic properties of the materials are considered through their refraction index (values in Fig. 1a refer to wavelength λ_0=1.55 μm). Planar interfaces are assumed perfectly smooth and infinitely wide at this stage of the work: wave propagation consists then of multiple reflections occurring in the xz plane (Fig. 1b).

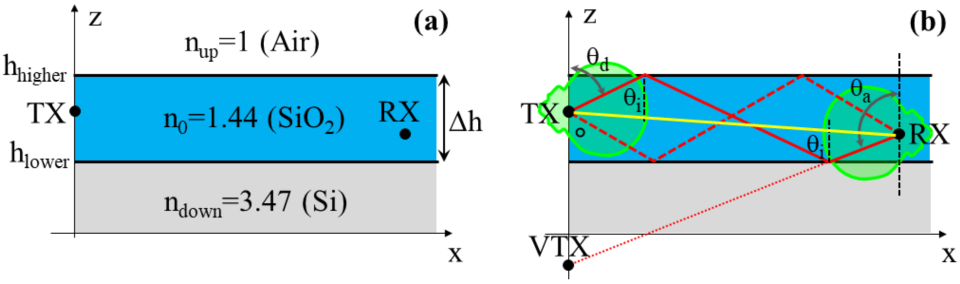

Fig. 1 – (a) Layered propagation environment; (b) Example: direct and double reflected rays between TX and RX

Therefore, the electromagnetic field radiated to the RX after n bounces (2 reflections are for instance shown in Fig. 1b) can be expressed as:

$$\vec{E}_n = \vec{E}_{0n} \cdot \frac{e^{-j\beta r_n}}{r_n} \cdot \Pi_n \qquad (1)$$

being $\beta=2\pi n_0/\lambda_0$ the wave number, r_n the overall length of the ray, Π_n the product of the n reflection coefficient, and $\vec{E}_{0n}$ the TX antenna "emitted field" in the direction of departure of the ray (θ_d in Fig. 1b). It is worth mentioning that the path length r_n can be regarded as the distance between the RX and an "n_{th} virtual transmitter" (VTX in Fig. 1b) that is the 'mirror' image of the TX (if n=1) or of the $(n-1)_{th}$ VTX (otherwise) with respect to the reflecting plane (image principle). In the considered layered scenario, closed-form analytical expressions for the VTXs locations can be easily achieved, meaning that the computation of both r_n and the incident angles (θ_i in Fig. 1b) are straightforward. Then, the (Fresnel) reflection coefficients (and therefore the value of Π_n) are also immediately available. Finally, $\vec{E}_{0n}$ is computed as:

$$\vec{E}_{0n} = \sqrt{\frac{\eta \cdot P_A \cdot g(\theta_d)}{2\pi n_0}} \cdot p(\theta_d) \cdot e^{-j\beta} \quad (2)$$

where $\eta=120\pi$, P_A is the overall transmitted power, $g(\theta_d)$ and $p(\theta_d)$ are the antenna gain and polarization vector in the direction θ_d. As previously mentioned, the power P_A and the 2D angular description of the antenna gain and polarization, required by the RT engine as input data, are obtained by using the FDTD. Assuming the same antenna at the RX side for the sake of simplicity, the same input information can be exploited to transform the impinging fields into the corresponding received power, once the ray directions of arrival (θ_a in Fig. 1b) have been evaluated.

IV. RESULTS

The RT model has been tested for the double interface Si-SiO_2-Air with a layer thickness ranging from 4 μm up to 10 μm, and for different positions of the TX and the RX within the layer. Moreover, different antennas patterns with increasing gain value have been considered at the TX/RX side, assuming an RX sensitivity of -20 dBm and P_A = 0 dBm.

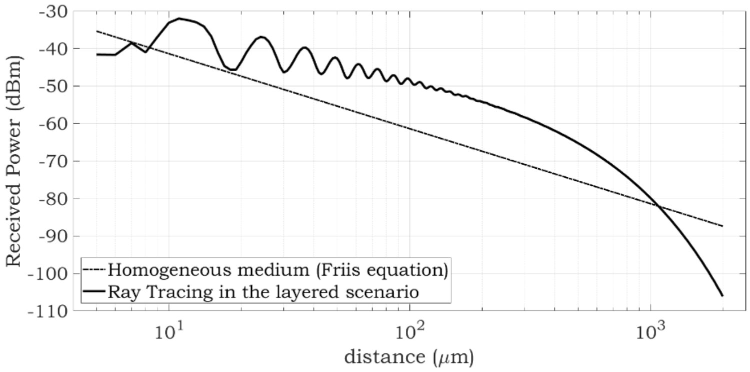

FIG. 2 – RT modeling of the in-layer propagation (layer thickness=4 μm, TX-RX middle placed, isotropic radiators)

Fig. 2 shows that a guiding effect (i.e. a greater received power compared to a fully homogeneous case) can be highlighted up to a breakpoint (BP) distance, which is strictly related to the layer width (the thinner the layer, the smaller the effect) and to the positions of TX-RX with respect to the lower interface (the closer the position, the weaker the effect). The guiding effect before the BP is mainly due to the overall constructive interference between the received field contributions. Beyond the BP, interference turns to become destructive, resulting in a received power weaker compared to the reference homogeneous case.

Besides the obvious beneficial effect of the layer, which acts as a guide, our analysis shows that the link performance is also affected by its width and by the antenna gain and position. This is shown in Fig. 3, where the maximum link distance, corresponding to a received power equal to the RX sensitivity, is plotted against the antenna gain for different TX-RX positions. If the gain is too low, a large amount of power is lost because of the large refraction losses of the rays far from grazing incidence, whereas the guiding effect is simply not triggered for gain values corresponding to an excessively narrow radiation lobe.

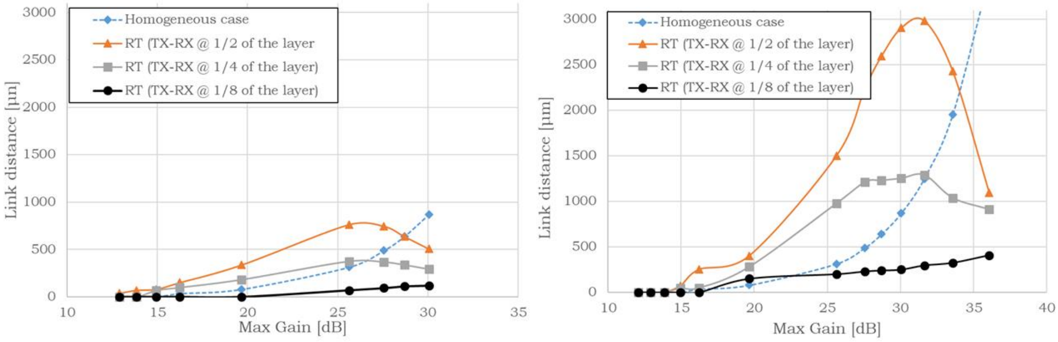

FIG. 3 – Link distance vs. antenna gain for different layer thickness: (a) 6 μm; (b) 10 μm.

In both cases, the link distance turns out to be impaired, to an extent which also depends on the layer thickness (Fig. 3a and 3b) and on the TX-RX positions within the layer (different curves in each figure).

V. CONCLUSIONS

Electromagnetic propagation for optical wireless network on-chip has been investigated using a ray-tracing approach. Assuming a layered layout for the optical wireless channel, which seems reasonable for multi-core chips grown in a multilayered structure, results show that the maximum link length does not increase simply increasing the antenna gain, but also depends on the thickness of the layer and the position of the antennas in the layer. This requires a strong interaction between the e. m. link and the electronic layout designers to find the optimum balance among the whole set of design parameters.

ACKNOWLEDGEMENT

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