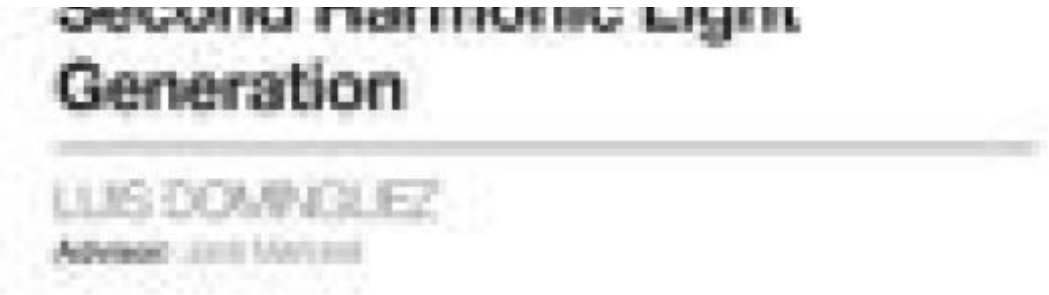

PhD Thesis Defense LUIS DOMINGUEZ 'Whispering Gallery Microresonator for Second Harmonic Light Generation'

LUIS DOMINGUEZ

July 22, 2014

Tuesday, July 22, 12.00. "Aula de Teleensenyament. Building B3. Campus Nord"

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In the last years, circular microresonators have been proposed as a future important element in the core of many photonic devices. The high Q-factors seen in fused silica micro-spheres and micro-toroids for light coupled in the whispering gallery modes (WGMs) inside the micro-resonator have led to many new developments in a diversity of fields. Indeed, WGM

micro-resonators have found applications in laser oscillation, optical filtering, bio and chemical sensing, frequency stabilization, quantum electrodynamics experiments, nonlinear parametric conversion and in many other light-matter interaction processes where light recirculation is an essential ingredient. For second and third order nonlinear optical phenomena a high-Q micro circular cavity is an ideal framework to lower the light intensity or material density and still obtain a measurable interaction. This may be particularly useful when the nonlinear interaction is considered on the sphere surface because, at an interface, centro-symmetry is always broken.

In this thesis, we approach the problem of obtaining Second Harmonic Light Generation (SHG) with the smallest amount of material possible. Our goal is to demonstrate that WGMs in micro-sphere resonators are an optimal option to consider such type of non-linear interactions. SHG obtained from a small amount of material may find interesting applications in high sensitivity unmarked detection of low concentrations of very small objects such as molecules, viruses or other types of nano-particles.

The different experimental and theoretical developments we implemented to achieve such goal are reported in the four chapters of the current thesis. In chapter 1 we introduce basic concepts of spherical micro-resonators and their interest. Theoretical aspects of light propagation and nonlinear light generation in the whispering gallery modes in such micro-resonators are discussed in Chapter 2. A new method to obtain patterns of a non-linear material is presented in Chapter 3. In Chapter 4, the developments presented in the previous chapters are combined to obtain second harmonic generation in the whispering gallery modes of microspheres. In this chapter we report the design and fabrication of a nonlinear spherical resonator to experimentally measure SHG from molecules deposited on its surface. Such nonlinear interaction is quasi-phase matched by implementing the periodical patterning reported in Chapter 3 on a molecular layer deposited on the surface of a micro-sphere. By coupling laser light pulses at the fundamental frequency into the whispering gallery modes of the high-Q spherical micro-resonators, we demonstrate that a signal at the second harmonic (SH) frequency can be measured when less than 100 molecules contribute in the nonlinear interaction. Finally, applications of such type of generation in highly sensitive sensing are discussed.

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Thesis Advisor: Prof Jordi Martorell