Summary

In recent years, there has been a growing interest in the use of photonic devices, partly due to the physical limitations that prevent further size reduction of electronic integrated circuits. This has led to the exploration of different physical phenomena/mechanisms that can be exploited in similar ways. Dielectric multilayers hosting Bloch surface waves (BSW) have emerged as a promising platform for nanophotonic devices due to their unique characteristics, which make them suitable for creating optical sensors and bidimensional photonic devices. Photo-responsive polymers have also gained interest in the manipulation of light in nanophotonic structures, as they have demonstrated their capabilities in responding to light stimuli in various ways [1–5]. They are, therefore, a promising platform for manipulating electromagnetic radiation.

Optical angular momentum is an interesting property of light that has found numerous applications in photonic systems. Angular momentum can be found either in the form of spin or in the form of Orbital Angular Momentum (OAM). In recent years, many nanophotonic devices have been developed to interact with and manipulate angular momentum [6–10]. However, it is becoming increasingly important to engineer photon sources directly[11, 12], especially in quantum applications where Single Photon Emitters (SPEs) are necessary [6–10]. Creating and engineering SPEs can be challenging, but recent research on two-dimensional materials such as Transition Metal Dichalcogenides (TMDs) and hexagonal Boron Nitride (h-BN) has shown promise. TMDs like MoS_2 and WS_2 have shown great reliability in

generating SPEs, but they mainly operate at very low temperatures [13–15]. Recent research on h-BN has shown that it is capable of overcoming this issue, and SPEs can be engineered by inducing or activating lattice defects in the material, despite its very high band-gap, which results in almost null photo-luminescence at room temperature [16–22].

In the aforementioned context, the aim of this project was to explore the possibilities offered by BSW-driven nano-photonic systems to manipulate light in new, unprecedented ways. The focus of this research is on the study of all-dielectric structures that enable subwavelength control of the spatial propagation of electromagnetic waves. This thesis is divided into three main activities presented in three different chapters, namely Chapters 2, 3, and 4.

One activity was aimed at exploring the use of photo-responsive polymers to control the resonance inside surface nanocavities. The optical anisotropy induced by polarized radiation was used to optically tune the resonance frequency of a circular nanocavity. This activity is detailed in Chapter 2.

A second part of this project is focused on the exploitation of BSW platforms for the manipulation of light emitted by dipole-like sources, with the goal of imparting an arbitrary angular momentum to the generated field. Specifically, we designed particular metasurfaces to generate circularly polarized vortex beams from dipole-like sources. This activity is reported in Chapter 3.

To test these platforms with actual dipole-like sources, our focus was directed towards researching reliable single photon emitter sources (SPE) that could be embedded into the designed photonic structures. We explored the use of hexagonal Boron Nitride as a means of providing SPEs by inducing defects on the crystal using localized focused ion beam damage. This activity is reported in Chapter 4.

In Chapter 1 instead, the theoretical and technical background useful for the understanding of the numerical and experimental methods utilised in this thesis is presented. In particular, the focus is placed on the mathematical implications of

Fourier optics, heavily exploited in the experiments, and on the description of the numerical methods utilised for modeling the structures.