Introduction

The demand of our society for communication seems to be insatiable. Despite recent backlashes in the optical networking business after the burst of the internet bubble, key industrial players identify optical networking as one of the most important future growth sectors. Optical communication networks have to expand capacity as traffic on the internet is growing exponentially, and the transmission of data is overwhelming the core of network systems, leading to significant congestion and delays. Yet, the demand will become far greater once video conferencing and further "bit-consuming" applications become widespread. Therefore, the society's enduring thrust for higher bandwidth data transmission systems and networks ultimately calls for innovative and cost-efficient photonic components with radically improved efficiency and speed. In order to realize cheap and yet powerful and efficient electro-optical devices the optical technologies and optical subsystems are actually poking at the utilization of bulk diffraction gratings. They represent key elements that could enable order to obtain economic advantages and flexibility in an all optical network. A *diffraction grating* is a collection of reflecting (or transmitting) elements separated by a distance comparable to the wavelength of the utilized light. It may be thought of as a collection of diffracting elements, such as a pattern of transparent slits (or apertures) in an opaque screen, or a collection of reflecting grooves on a substrate. A *reflection grating* consists of a grating superimposed on a reflective surface, whereas a *transmission grating* consists of a grating superimposed on a transparent surface; the fundamental fact is that, upon diffraction an electromagnetic wave impinging on a grating will have its electric field amplitude, or phase, or both, modified in a predictable manner.

The focus of this work is the study of periodic structures which are called *holographic diffraction gratings*, since they are realized by utilizing the interference pattern generated by two (or more) interfering beams. Our goal is to fabricate and characterize these structures made different organic materials, in order to realize opto-electronic devices that exhibit good functionalities for optical communication systems. The first chapter of this thesis outlines a rigorous coupled - wave approach, which can be used to analyze diffraction general planar gratings, bounded by two different media. The purpose of this short introduction is to clarify the meaning of the well know definitions of *thin* and *thick* gratings. In the second chapter, we report on the realization of a new optical setup which utilizes an optical–feedback–driven nanopositioning technique; this is mandatory to obtain a uniform and sharp morphology of gratings. We have enhanced the stability of the interference pattern by means of a simple piezomirror used in a feedback device that keeps constant the relative phase between the two interfering beams. The feedback is driven by a proportional, integral, and derivative control algorithm, while the stability degree is cheked by utilizing the reference signal coming from a standard test grating. A preliminary experimental study indicates that a good stabilization and control of parasitic fluctuations of the interference pattern can be realized.

The possibility of developing electrically switchable holographic gratings in polymer dispersed liquid crystals (PDLC) has been widely explored in the last 15 years. Although these devices have good diffraction efficiency and low cost, they exhibit some intrinsic drawbacks. Namely, if the droplet size of the nematic liquid-crystal (NLC) component inside the polymer matrix is comparable with the wavelength of the impinging light, the sample is strongly scattering. Recently it has been developed a new kind of holographic grating that exhibits better optical quality. The grating consists of polymer slices alternated with films of regularly aligned NLC and has been called POLICRYPS, acronym of polymer liquid-crystal polymer slices.

These novel structures can be used for optical communication, and optical data storage and processing due to their electro-optical characteristics. In the third chapter we discuss on the realization of tunable waveguides that make use of a POLICRYPS grating. The basic idea is very simple but innovative enough to be considered as a new way to obtain low cost components which can be used as a wavelength selective optical filter. Such a filter is composed of an ion-diffused glass optical channel with a POLICRYPS grating on top. A light beam propagating inside the guide is affected by the presence of the index modulation of the grating, this modulation produces a filter action for the light inside the guide. The final result is a notch filter, namely, a filter that passes all frequencies except those that are included in a stop band centered on a particular frequency. By applying an external electric field it is possible to modify the refractive index modulation and hence to tune the stop band. This is potentially the core of a simple and inexpensive technology to realize integrated optic functional components. Design concepts and tools, fabrication issues and experimental findings of novel tuneable and switchable integrated optic components will be described and discussed.

The rapid developments in information and communication technology in recent years have been facilitated to a large extent by technological and industrial progress in the production of portable Liquid Crystal Displays (LCDs). For instance, transflective LCDs films are widely used in mobile phones or Personal Digital Assistants (PDAs) while transmissive LCDs films are commonly employed in notebook computer screens and recently in desktop computer screens. Both types require an illumination system, behind the screen (conventionally a backlight system), where light comes from towards the LCD. Unfortunately, the light management in present liquid crystal displays (LCDs) is not very efficient. One of the factors limiting the light throughput is the absorption in the colour filters; it has been shown that a promising way to reduce this absorption is the use of diffractive colour separation by a grating on top of a lightguide in the backlight system.

Another factor that limits the light throughput is absorption in the polarisers. This absorption can be avoided by using a polarised backlight, that is, a backlight that only couples out light of a specific polarisation. This can be accomplished by the use of a birefringent material applied on a microstructured light guide. Recently, it has been shown that it is possible to combine colour separation with polarised light emission by using a surface-relief grating with a birefringent coating. In this way, also the absorption in the polarisers can be reduced. During my Internship at *Philips Research Eindhoven (NL),* I had the opportunity to investigate this kind of systems: The basic idea was to realize holographic diffraction grating with large area and uniform morphology. The last chapter will first discuss the principles of operation of a colour-separating backlight system and then will discuss experiments on such structure. Some interesting results are discussed, concerning a small and uniform grating a peculiar technique introduced in order to pattern a large area substrates with a step and repeat process will be discussed. Finally, the possibility of integrating this kind of gratings in a backlight display system will be examined.