CHAPTER 7

CONCLUSION AND FUTURE SCOPE

7.1   CONCLUSION

The purpose of this chapter is to review and draw conclusions from the work presented in this thesis and to suggest areas for future work. The design of Optical MEMS component for electronic systems remains a challenging task today. There is indeed a need for low-power and small size circuits. In the beginning of this chapter the basic principle and necessity of Optical MEMS technology has been discussed.

In the third chapter, the Electrostatic analysis of MOEMS component was carefully studied in order to improve their performances. In this work, several tools for characterizing the efficiency of GLV are provided. The effective deflection, reflectivity, gap, and width are some of these tools. In this thesis, as a first step a mathematical model was developed to find the fringing effect in micro beams. Grating Light Valve, a diffractive component was used throughout this chapter. An accurate evaluation of the deflection of active ribbon is necessary to estimate correctly both the output power and the intensity. The fringing field is a source of error which mainly reduces the efficiency of electrically conducting microstructures. Two mathematical models were used to analyze the structure. In the first model, a mapping method is used to find the fringing effect and in the second model, by solving the Laplace's equation with appropriate boundary conditions, the result is evaluated. Since the mapping method is very simple to evaluate the variables,

it is well adapted to analyze this problem. The significance of this simple approach is that it allows to find the fringe radiation field as a field map.

In the second mathematical model using the solution of simple Laplace's equation, the fringing field is identified. The separation variable method is more appropriate to solve the Laplace's equation and to find the electric field and the equipotential line outside the conductors region. The describing functions formalism is used for that purpose, as it gives the best match with the software model. It is shown through mathematical explanation that there is an effect of fringing field in the biasing ribbon. It is also verified through software analysis. Based on mathematical analysis, it is explained how the signal voltage is induced in the biasing ribbon due to the fringing effect. The measurements indicate that the deflection of biasing ribbon reduces the ideal deflection and the resultant is called effective deflection. It is seen that, within the threshold voltage, the deflection of biasing ribbon due to fringing field reduces the efficiency of the Grating Light Valve. Ribbons 3 and 5 are deflected more than the first ribbon, as it has a symmetrical active ribbon on both sides. Below the threshold voltage, the input-output light intensity relation depends on both the width (w) and deflection depth (δ) of the ribbon. Furthermore, due to the effective deflection the output light intensity is less compared to the ideal deflection. The comparison of mathematical model with CoventorWare result proved that the mathematical analysis is exceptionally useful for determining fringing field effects in electrically conducting microbeam structure. The curve of ideal deflection (δ_{ideal}) versus applied voltage (V) and effective deflection (δ_{eff}) versus applied voltage (V) for a particular wavelength are plotted. It shows that the effective deflection is less than the ideal deflection. This means that the fringing effect reduces the ideal deflection. Again the normalized intensity due to ideal deflection and effective deflection for the same input control voltage has been

identified and plotted. This shows that the intensity is also reduced due to the effective deflection.

In the fourth chapter multilayer ribbon is introduced to increase the reflectivity of GLV. Sophisticated MEMS display models were previously developed to fulfill the drawbacks of the bulk ones. Following this general analysis, there are two ways of improving the performances of Grating Light Valve. Firstly, technological efforts improve the reflectivity of the top layer. A multi-layer structure is investigated. Multi-layer structure provides better performance than the bare metal coatings. Furthermore, the output intensity increases with the reflectivity of the top layer of ribbon and gap reflectivity between two ribbons. The deflection depth and width of the ribbon are other important parameters, since their impact on both the efficiency and wavelength tuning are quite appreciable. In this chapter, emphasis is given to improve the reflectivity of the top layer of the Grating Light Valve. A design strategy is developed based on the multi-layer structure. The simplicity of the proposed modelling presents the advantage that, without losing accuracy, the real time processing is possible and it gives insight into the non-linear behaviour. A good evaluation of the efficiency requires a good evaluation of the output light intensity. The designer has to choose between the insight provided by tools and the accuracy of models. CoventorWare is used for the analysis. It is a powerful tool for the analysis and the design of MEMS components. Based on that formalism and MEMS analysis, a top-down design methodology is proposed to optimize the performances of GLV. Even if the method remains to be validated experimentally, it improves the accuracy of the designs and allows it to deal with the trade-of between opposing manufacturing technology and spectral purity. The performance can be improved by integration of the multi-layer structure at the top of GLV ribbon. The analysis allows for reflection coatings deposited on the facet and it has been shown that for certain coating refractive indices and coating thicknesses,

reflectivity can be increased. In chapter 4, a method to increase the reflectivity of the top layer of the GLV ribbon is explained. It is shown that adding a layer of stack with high and low refractive index increases the reflectivity and this property finds important application in the design of display with high resolution. The calculated reflectivity for the addition of a stack with high and low refractive index material shows that the reflectivity has been increased. The obtained results show the intensity distribution of first order diffraction of the output from the GLV with and without the additional stack on the top layer (Aluminium coating) of the ribbon around the focal point for a fixed wavelength 0.64 μm. This shows that the intensity increases after adding a high reflectivity layer on the ribbon.

The increasing requirements for display applications demand high performance systems-on-chip today. 'High performance' means low power consumption, high quality of the image resolution and low volume and weight. If the IC scaling contributed to performance improvements, we are now confronted to short-switching speed and to the relatively poor quality of the passive integrated components. This requires the development of adapted modelling and characterization tools. So, one can move from standard bulk CMOS to other technologies. The very high switching speed strongly depends upon the mechanical force, which can be utilized to construct highly dispersive optical devices and components. Such devices include high-resolution wavelength-division multiplexers/demultiplexers that have great potential for application in the display units. In that case, the development cost is high, but the expected gain is also high. Finally, if high quality components help to improve the quality of the systems, the performances also highly rely on the systems and circuits architecture. The goal of the present work in chapter 5 is to improve crispness of the edge detection. It has been proved that using Grating Light Valve; the edge detection can be accurately done. This design improves the performances of output crisp edge detected

picture. This method is more accurate since the detection of the edges of the picture is displayed by the Grating Light Valve. The Grating Light Valve could be used to improve the accuracy of edge detection and thereby the quality of image. The clear advantage of this approach is that very accurate results may be obtained with minimal computational effort when compared with traditional numerical techniques such as the Finite Difference and Finite Element methods. Moreover it is very easy to integrate with the conventional circuits. This analysis indicates that the finite-size of GLV pixel provides better crispness than other displays. The major advantage of this method is that there is no need to impose complex circuit arrangement to detect the edges.

In chapter 6 GLV technology is used as an alternative to bulk CMOS technology. Micromachining technologies are used to fabricate tunable passive components. Finally, circuit design techniques for non-linear wave length filters are investigated in this chapter. The quality of the wavelength separation depends on the mechanical and electrical parameters of the system. A classical procedure for dealing in a practical way with non-linear systems is to construct an image processing transceiver unit for the better transmission of image signals. The very high switching speed of Grating Light Valve strongly depends on the mechanical force, which can be utilized to construct a display system and a variation in deflection depth depending on the control voltage which results in highly dispersive (phase diffractive) wavelength tuning system. Wave length selective filters can be implemented using array architectures consisting of GLV. In this design, the different width and deflection depth of ribbons constitute the movable plate of GLV to tune the different colours and their displacement is independently controlled by the voltage applied across the top conducting plate and ground plane of the GLV system. The deflection depth can be controlled by external control voltage. But the width of the ribbon is decided during the design and

manufacturing. The simplicity of the proposed modelling presents the advantage that, without losing accuracy, the real time processing is possible and it gives insight in the non-linear behaviour. Compared to the other display devices, as the switching speed of GLV is extremely high, the device fulfils the requirements of the   state-of-the art projection equipments.

7.2   FUTURE DIRECTIONS

The concept of electrical field coupling in MEMS components and its impact in efficiency is developed and discussed for the first time. Due to the simplicity of the GLV, the system lends itself to the analysis of a wide variety of other applications in integrated optics. An important parallel work in underway is an application of the Grating Light Valve in deformable mirror in ground based telescopes. Future work includes the application of Grating Light Valve in bio-medical equipments to detect the heart problems. Due to the fact that the order of diffracted light signal from GLV is determined by the deflection depth of the active ribbon, this heart signal makes it easy to achieve a visible output. To enable the detecting operation, the heart signal is applied to the cross correlator which has a reference heart signal. The disparity between the two signals is applied to the GLV which produces the diffracted image. According to the movement of the signal from zeroth to first order, one can find the abnormalities in the heart of humanbeings. However the suggested system cannot diagnose the specific problem, it effectively produces the visual information about the condition of the heart. Another possible work includes the design of high-resolution wavelength-division multiplexers/demultiplexers using GLV that have great potential for application in the telecom system. This thesis can be further extended to analyze multi layered structures which incorporate high and low refractive indices. A key feature of the GLV array is that the individual direction elements have no physical boundaries, or dark spaces between elements. This

feature facilitates certain applications in optical communication such as designing of dense wavelength division multiplexing (DWDM) channel count.

The evolution towards integrated Microsystems renders the design of MOEMS more multi-disciplinary than ever, requiring skills at several levels, from the development of fabrication tools to the design of transmission system. The mechanical functions in MOEMS require adapted materials. Thin-film Technology is considered for its potentiality in the realization of high sensitivity sensors and for its integration with state of the art SOI electronics. The main concerns related to micro technologies, apart from the development of efficient CAD tools, are today linked to the fabrication and the reliability of the devices. Some material properties may differ at the micro-scale since the volume to surface ratio decreases.

The above thesis work has been successfully disseminated through a number of national and international publications and conferences. This conclusion has significant consequences for the future of optical simulation as ever more demanding performance and specifications are required. With the ever increasing demands being placed upon Micro Opto Electromechanical Systems, it is inevitable that this demand will motivate one to continue research in developing accurate simulation tools for the analysis of integrated optics.