ABSTRACT

This dissertation explores the feasibility of a new design for an optical cross-connection (OXC) device based on combining Micro-Electro-Mechanical Systems technology (MEMS) with an optical system called the White cell. The attractive feature of our design is that is a 3D design using a digital MEMS. This leads to a high number of ports and uses a simple control system for the MEMS.

We demonstrate two different systems: a quartic configuration and a binary configuration. This is the first demonstration of either of these configurations as OXC systems.

For the binary configuration we design and simulate three different spot displacement device (SDD) designs of our own creation: Tilted spherical mirror SDD, roof prism SDD and lens train SDD. We evaluate each design in terms of aberrations where the SDDs are configured to provide displacements of 500 μm and 2000 μm. From this evaluation we conclude that the roof prism SDD has the best performance of the three with a maximum astigmatism of 0.0013 mm. We simulate an 1x8 binary OXC system using the roof prism SDD.

An underpopulated quartic cell is simulated and experimentally analyzed. The main objective of these experiments is to prove that is possible to switch any input to any particular output by controlling the titling mirrors of a MEMS. Due to the lack of a MEMS, we designed and made a "pseudo-MEMS," a structure whose main

function is to imitate the characteristics of a proper MEMS, except that it cannot be reconfigured in real time. We are able to control the output row by sending the beam to specific spherical mirrors as predicted. Because the optical elements are uncoated we found an experimental loss of 27.54 dB per output. If we assume coated optical components the theoretical loss is only 2.46 dB for seven bounces.

Another contribution of our work is to address the problem of beam coupling at the output plane for any White cell-based OXC. Our solution is based on curved a diffraction grating that takes advantage of a free-space architecture that makes it compatible with our OXC designs.