
Direct Photonic Beam Steering

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A Direct Photonic Beam Steering (DPBS) device has been studied which is intended to be used as a large scale all optical switch array or active fiber alignment devices for communication networks. The objective of the research is to steer optical fibers directly with up to five degrees of freedom, so that light beam from any input ports can be sent to any output ports, satisfying the optical and operational requirements. The technology is enabled through the integration of microelectromechanical systems, thin film piezo actuators, optical engineering technologies, and Axiomatic approach to systems design. The curved electrode electrostatic and thin film piezoelectric actuators were simulated in advance to the microfabrication processes. This technology has the potential of many novel applications such as: all optical switching, microendoscopy and gazable microeye as well as active fiber alignment.

The DPBS system concept utilizes two parallel planes along the fiber axis. The actuation plane is located between two hinge planes with distance, d and L . A fiber can only rotate without moving its center position on each hinge plane. Distance L is long enough to provide a slack for the movement of a fiber on the actuation plane. Having relative motions, $_x$ and $_y$, of the fiber tube on the actuation plane defines tilt angles, $_x$ and $_y$, at the end of the tube. Since the photonic beam will proceed straight along the tangential line at the tip of the fiber, DPBS manipulates the optical fibers directly so as to guide the optical beam to the desired direction as shown below. Translational motions, $_x$ and $_y$, can be obtained by having two actuation planes along the fiber axis.

Choice of micro actuator is critical for the micro-photonic beam steering system. Mathematical models have been developed for choosing and designing actuators for the requirements specified. The models are compared and optimized for the minimization of the stress and bending losses in the optical fibers. MEMCAD, a

MEMS simulation Finite Element software, has been used to simulate the curved electrode and thin film PZT actuators. The simulation results have shown that the force the curved actuator could provide is not big enough. To satisfy the force requirement, the size of the electrostatic actuator becomes too large. The thin film PZT actuator is simulated using the thermal coefficient equivalent method. The simulation results have shown that the thin film PZT actuator with the associated displacement amplification mechanism can satisfy both the force and displacement requirements while maintain its compactness. The device is being fabricated using both surface and bulk micromachining methods. A lay-out of the device is shown below.