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Moving reflector type micro optical switch for high-power transfer in a MEMS-based safety and arming system

Kevin R Cochran[1,2], Lawrence Fan[2] and Don L DeVoe[1]

[1] Department of Mechanical Engineering, University of Maryland College Park, MD 20742, USA
[2] Indian Head Division, Naval Surface Warfare Center, Bldg 302, 101 Strauss Avenue, Indian Head, MD 20640, USA

E-mail: cochrankr@ih.navy.mil

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Abstract
Development of a moving reflector type micro optical switch fabricated by deep reactive ion etching (DRIE) in silicon on insulator (SOI) substrates is presented. The device discussed is a key component in a MEMS-based safety and arming (S&A) system for use in underwater weapons. In this switch, an etched vertical sidewall reflector is electrostatically actuated in and out of the optical path between input and output optical fibers. Fabrication is performed on 100 μm thick silicon substrates with fiber alignment channels, reflectors and actuators being fabricated at the same time with a single etch step. A single pair of multimode fibers is used to transmit optical power of the order of 1000 mW at a working wavelength of 810 nm. Sources of optical loss in the system are identified and their value calculated in order to predict the overall system optical efficiency. The optical efficiency of the switch has been found to have an average value of 55% with the etched vertical sidewall mirror having an average reflectivity of 62.8%. Switching time is 10 ms from the off to the on state with a maximum operational frequency of 60 Hz. Isolation between the on and off states is 32 dB.

1. Introduction

An optical micro switch for high-power transfer has been developed for integration into a MEMS-based safety and arming (S&A) system. The S&A system is currently being developed by the Indian Head Division, Naval Surface Warfare Center and is intended for use in underwater weapons. The purpose of the S&A system is to prevent unintended detonation of a weapon while ensuring that detonation will reliably take place when needed. The first generation of the MEMS S&A device used LIGA processing to create a movable barrier that physically interrupted an explosive train initiator [1].

This paper describes the second-generation device in which the electrical power to the initiator system is interrupted by optical means. The system provides fail-safe activation and termination of an optical path between a low-power source and a high-power discharge capacitor. A schematic of the system is shown in figure1.

A key component to this system is a MEMS-based optical interrupter chip. The interrupter has been investigated previously using LIGA processing [2]. The optical output from a laser diode (LD) is fed to the interrupter chip through an input optical fiber. On-chip components include an optical switch along with environmental sensors and locks, which are necessary for proper S&A system operation. The optical output from the interrupter is sent to a photodetector through an output optical fiber. The electrical output from the photodetector is in turn sent to a power conversion circuit and finally to a high-voltage discharge capacitor.

In order for the discharge capacitor to charge sufficiently, the output photodetector must provide 5 V and 80–100 mA for 500 ms to the power conversion electronics. A photovoltaic power converter is used for optical to electrical power