Integrated Optical-wavelength-dependent Switching and Tuning by Use of Titanium Nitride (TiN) MEMS Technology

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Ring resonators are integrated optical components that have the capabilities to filter specific bands of wavelength from a broad-band input signal. Although these devices themselves are passive components, by use of evanescent field coupling, the ring resonator can be switched or tuned by electrostatic actuation of a MEMS bridge-type structure above the ring waveguide (Figure 1). This procedure of switching and tuning will allow for a faster speed than thermal tuning and will not induce severe loss, as does carrier injection.

One major issue that must be faced when implementing this concept is the residual stress that the MEMS bridge structure exhibits. Precise vertical positioning of the bridge is crucial for this type of device, and hence the bridge structure must not deflect due to residual stress within the structure. Use of TiN was investigated as the structural material due to its appealing mechanical properties, high electrical conductivity as well as its ability to relax its residual stress by annealing.

The TiN MEMS bridges were fabricated and tested. The MEMS structures were successfully annealed to a flat state, and the actuation voltage of the switch was 90V (Figure 2).

Recently, we have been investigating an architecture which allows for a more flexible design of the device, as well as the capabilities for implementing ultra fast-switching and feedback control of the position of the wafer via capacitance measurement [1]. In this architecture, the ring resonator is fabricated on one wafer and the MEMS structure on another, and the wafers are flip-chip bonded by thermocompression waferbonding with gold.

Wavelength tuning of the ring resonator filter has been numerically simulated by a combination of FEM structural analysis and mode-solver electromagnetic analysis. This analysis showed that tuning of a range of 30 nm with an actuation voltage of 10V was feasible with a silicon oxynitride membrane as the dielectric material.

![Figure 1: Concept of ring resonator switching via evanescent field coupling (top) and the implemented MEMS-based switching device (bottom). The same concept can be used to tune the resonating wavelength of the ring resonator by using a dielectric material instead of a lossy material, in which case the dropping wavelength on the top left figure will be altered to another wavelength when the membrane is pulled down close to the ring resonator.](image1)

![Figure 2: The profile of the TiN MEMS bridge before and after annealing at 500°C (top), and the voltage vs. deflection curve of the actuated MEMS bridge (bottom).](image2)

REFERENCES