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**Dissertation Defense**  
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## **MEMS-tunable vertical-cavity SOAs**

### **ABSTRACT**

Vertical-cavity semiconductor optical amplifiers (VCISOAs) are attractive as a low-cost alternative to existing amplifier technologies for use in fiber-optic communication systems such as metro and access networks. In contrast with in-plane SOAs, the surface-normal operation of vertical-cavity SOAs gives rise to a number of advantages including a high coupling efficiency to optical fiber, polarization insensitive gain, the potential to fabricate high fill-factor two-dimensional arrays, and the ability to test devices on wafer.

Due to their narrow gain bandwidth, VCISOAs function as amplifying filters. In these devices the inherent spectral filtering of the high-finesse Fabry-Pérot cavity leads to the elimination of out-of-band noise and results in channel-selective amplification. For multi-wavelength communications systems, it is of great interest to develop widely tunable VCISOAs that can be dynamically adjusted to match the signal wavelength. A promising approach to achieve wide wavelength tuning in VCISOAs is micromechanical, or MEMS-based tuning. Here, mechanical alteration of the effective cavity length gives rise to tuning ranges greater than those that can be achieved via refractive index modulation.

This dissertation outlines the development of three generations of MEMS-tunable VCISOAs (MT-VCISOAs), with the initial generation of devices being noteworthy as the first demonstration of a micromechanically-tunable VCISOA. In contrast with temperature tuning, the AlGaAs-based electrostatic actuator used in these devices allows for rapid, low power, and wide wavelength tuning. In the final generation, the MT-VCISOA utilizes a bottom-emitting configuration in which the MEMS-tuning element serves as the high-reflectivity back mirror. By suppressing the variation in reflectance with tuning, this configuration exhibits a two-fold increase in the effective tuning range as compared with the initial generation of devices—with a minimum of 5 dB fiber-to-fiber gain (12 dB on-chip gain) over a wavelength span of 21 nm, from 1557.4 nm to 1536.4 nm, while requiring a maximum tuning bias of 10.5 V (a five-fold reduction when compared with the first generation of MT-VCISOAs). Furthermore, these devices exhibit properties comparable to state-of-the-art fixed-wavelength VCISOAs, with a maximum fiber-coupled saturation output power of -1.4 dBm and an average gain bandwidth and noise figure of 65.2 GHz and 7.5 dB respectively.