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WL61

New thermal stabilizing control of acousto-optic tunable filter using digital feedback technique

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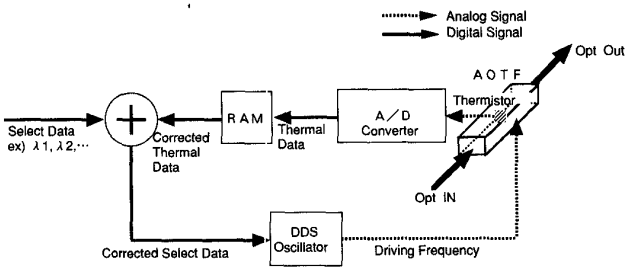
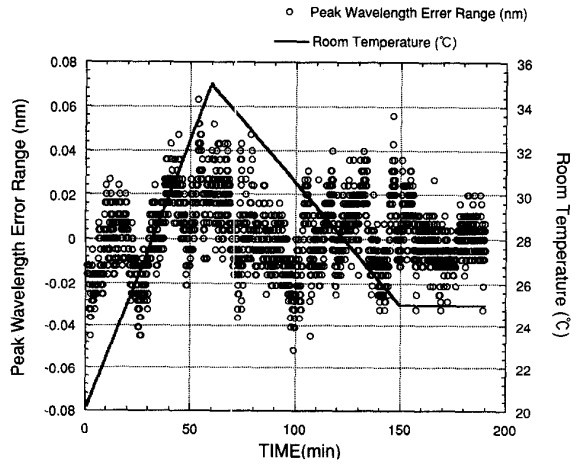
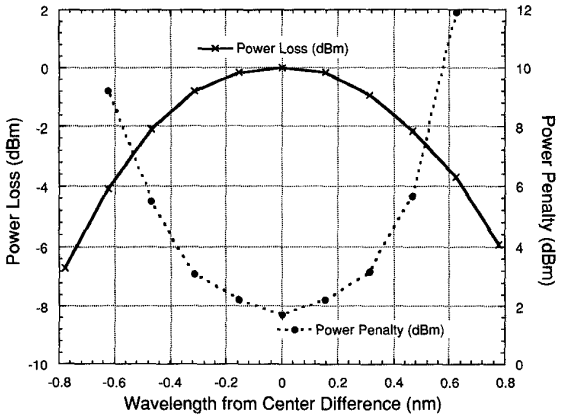
Tunable filter is one of the key devices for the future wavelength-division multiplexing (WDM) system. The acousto-optic tunable filter (AOTF) has many advantages such as fast tuning speed and high resolution power.[1] But, the selected wavelength by AOTF is varied by the influence of ambient temperature due to the temperature dependency of $LiNbO_3$ as this device material. Therefore, there is a formerly stabilizing technique of AOTF by way of constant temperature control with Peltier elements.[2] But, there are problems that the electric power consumed mainly by Peltier element and the scale of circuit become large in this way. We propose the new technique of stabilizing control of AOTF using digital feedback technique.



WL61 Fig. 1. Configuration of stabilizing circuit.



WL61 Fig. 2. Stability of wavelength control.



WL61 Fig. 3. Transmitting power and power penalty of AOTF.

We constructed the WDM network system of eight wavelength channels with channel separation of 3.2 nm. In this system, the total stability of wavelength tuned by AOTF is necessarily under about 0.1 nm. The configuration of our stabilizing circuit is shown in Fig. 1. To obtain the necessary wavelength stability, we use direct digital synthesizing (DDS) technique to generate the driving frequency of AOTF. Thermal data from thermister is A/D-converted, converted to the correction data stored in memory, added with the channel select signal and input into the digital input port of DDS oscillator.

By this controlling method, it became possible to reduce the electric power consumption and the circuit size. The satisfying stability of wavelength control under ±0.065 nm was obtained in room temperature by our method as shown in Fig. 2. The power penalty that occurs on AOTF in the condition of the bit error rate <1E-10 is shown in Fig. 3 and the bit rate of signal was 2.5 GHz. The reason for this power penalty depending on the deviation from the center wavelength of AOTF is now under investigation.

In spite of the influence of this power penalty, enough tunability of AOTF and enough signal-to-noise ratio were obtained by our new method using digital feedback technique.

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Integration of polymer waveguide electro-optic modulators and VLSI electronics using standard lithographic fabrication techniques

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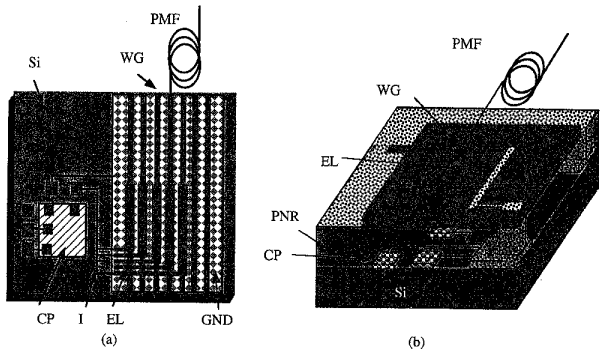
Over the last few years, electro-optic (EO) polymers have reached the state of technological maturity where devices for practical applications become feasible. For example, polymers with EO coefficients stable up to 300°C[1] and r_{33} coefficients of 55 pm/V[2] have been discovered recently. The ease with which polymers can be processed into multilayer devices by standard Si processing techniques makes them attractive for optoelec-

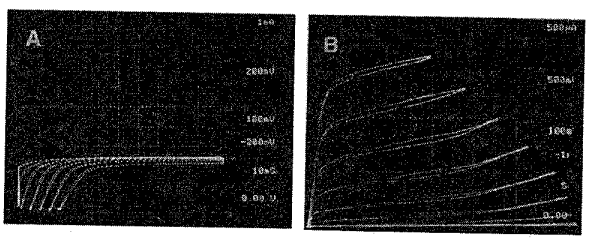


WL62 Fig. 1. The two architectures for the integration of polymer modulators and VLSI electronics: (a) vertical integration. PMF: polarization-maintaining single-mode fiber, WG: waveguide, CP: electronics chip, I: interconnects, EL: modulator electrode, GND: ground plane; (b) Side-by-side integration. PNR: polymer planarizer.

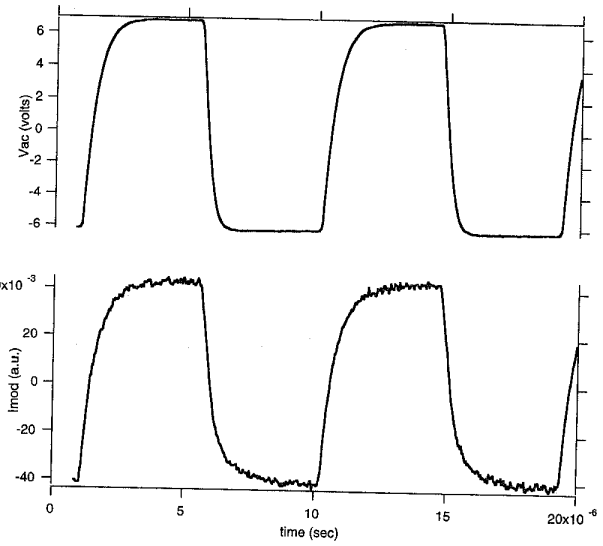
tronic integration. Also desirable is their potentially low cost, the ability to synthetically tune optical properties such as refractive index and transparency, and electrical properties such as conductivity and dielectric constant. Devices with extremely high speeds (currently 60 GHz)[3] and low optical loss at the telecommunication wavelengths have been demonstrated. The monolithic integration of alternate crystalline materials like $LiNbO_3$ with Si electronics is difficult because of processing and lattice constant mismatch constraints.

We have used two architectures to demonstrate the integration of polymers and electronics (Fig. 1). In our vertical integration scheme, the photonics device is integrated directly above the electronics devices with an intermediate dielectric layer for isolation and planarization. We will describe our progress on many of the critical technologies that are needed for the monolithic integration of VLSI circuits and polymer modulators such as (i) planarization, (ii) protection of circuits to high voltage poling, (iii) interconnect vies in polymers and (iv) automatic v-groove alignment. Protection of the circuits during the high-voltage polymer poling process, for example, is a critical issue. In Fig. 2, we show the I-V results for dummy polymer modulators on GaAs MESFET circuits with and without a ground plane protection scheme.

A full demonstration of vertical integration requires a processed Si wafer with circuits over a 2 mm × 1 cm area, because current polymer devices must be at least 1 cm long to develop detectable modulation. Commercially available unpackaged ICs, on the other hand, are rarely larger than 2 mm × 2 mm. Therefore, to demonstrate a fully working polymer-Si "opto-chip," we have used an alternate architecture that circumvents the size issue. In this side-by-side integration scheme, the photonics and electronics devices are integrated adjacent to each other



WL62 Fig. 2. Protection of GaAs MESFET's during polymer high-voltage poling and device fabrication procedures. (a) I-V of device subjected to fabrication procedure without ground plane protection scheme. (b) I-V of protected device showing no degradation of the electronics.



WL62 Fig. 3. Testing results for side-by side integrated polymer-Si chip. Upper curve is the driving waveform of the LCD chip. Lower curve is the detected modulation from the waveguide.

on dedicated areas of the substrate. In a fully monolithic fabrication sequence, the electronics would be fabricated first and a sufficiently large portion of the wafer would be left free for the photonics device. Because such a scheme would involve custom chips from the foundry, we have opted to follow a quasi-monolithic fabrication sequence. In this sequence a commercially available LCD driver chip 1 mm × 1 mm was combined on the same Si substrate with an array of polymer modulators. Interconnects between the chip and modulator were made by photolithographically predefined metal lines. Figure 3 shows the testing results for a fully integrated PURDR19 electro-optic polymer phase modulator driven by the on-chip LCD circuit. Details of the architectures, fabrication techniques and the design of a 500 MHz modulator driver chip are discussed.

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