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# Ultrafast Differential Sample and Hold using Low Temperature grown GaAs MSM for Photonic A/D Conversion

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**Abstract:** We demonstrate an ultrafast sample and hold circuit using optically triggered metal-semiconductor-metal (MSM) switches made of low temperature (LT) grown GaAs for use in a photonic A/D conversion system. We incorporate a differential configuration to reduce feedthrough noise.

Many proposed photonic A/D conversion systems consist of an input electrical signal biasing an optical modulator whose output is optically de-multiplexed to an array of electrical A/D converters [1,2]. However, the speed and linearity of the optical modulator limit the performance of these systems. To circumvent this problem, we propose a sample and hold scheme utilizing LT grown GaAs MSM switches. The short recombination lifetime and high mobility of LT grown GaAs allow high-speed operation with good sensitivity [3]. Optically triggered by a short pulse laser, the switches would be attached to a transmission line and would sample the input electrical signal onto a hold capacitor.

One potential drawback of this scheme is the capacitive feedthrough from the input signal corrupting the sampled voltage on the hold capacitor. We resolve this issue with a novel differential configuration.

The switch response was characterized by placing the MSM in the middle of a coplanar waveguide transmission line structure and performing an electro-optic sampling measurement. A titanium/gold contact was deposited for both MSM and transmission line patterns. The ultrafast response (1.6 ps FWHM) of the switch is evident (Fig. 1a). Different speeds and responsivities were obtained by varying growth temperature, post-growth anneal conditions and the MSM pattern.

The sample and hold test pattern was made by attaching the MSM switch and hold capacitor in series across the signal and ground lines of a transmission line. Electro-optic sampling was used to measure the voltage across the hold capacitor (Fig. 1b). We believe the ringing of the signal is due to some parasitic inductance in the test pattern. The inset of Fig. 1b shows the held output signal as a function of the DC input signal. The linearity of the graph confirms the accuracy of the sample and hold process. The held output signal was taken 100 ps after the leading edge of the electro-optic signal to avoid effects from ringing.

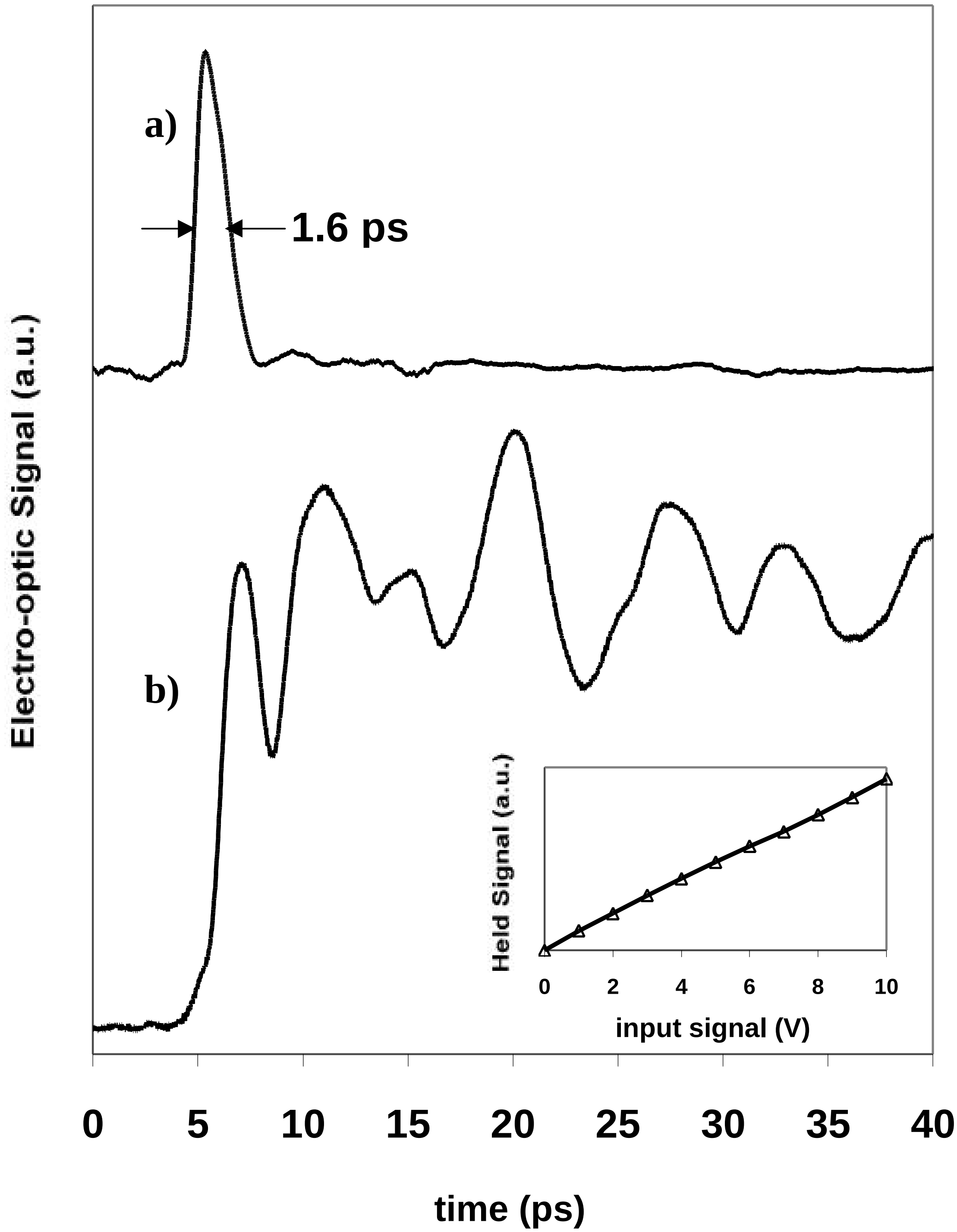


Fig. 1. a) Switch response for a 2 μm finger spacing MSM. Sample was grown at 250°C and annealed at 600°C for 1 minute. b) Sample and hold of DC input signal. Sample was grown at 250°C and annealed at 800°C for 1 minute. Inset shows the held output signal as a function of DC input signal. Good linearity demonstrates the accuracy of the sample and hold process.

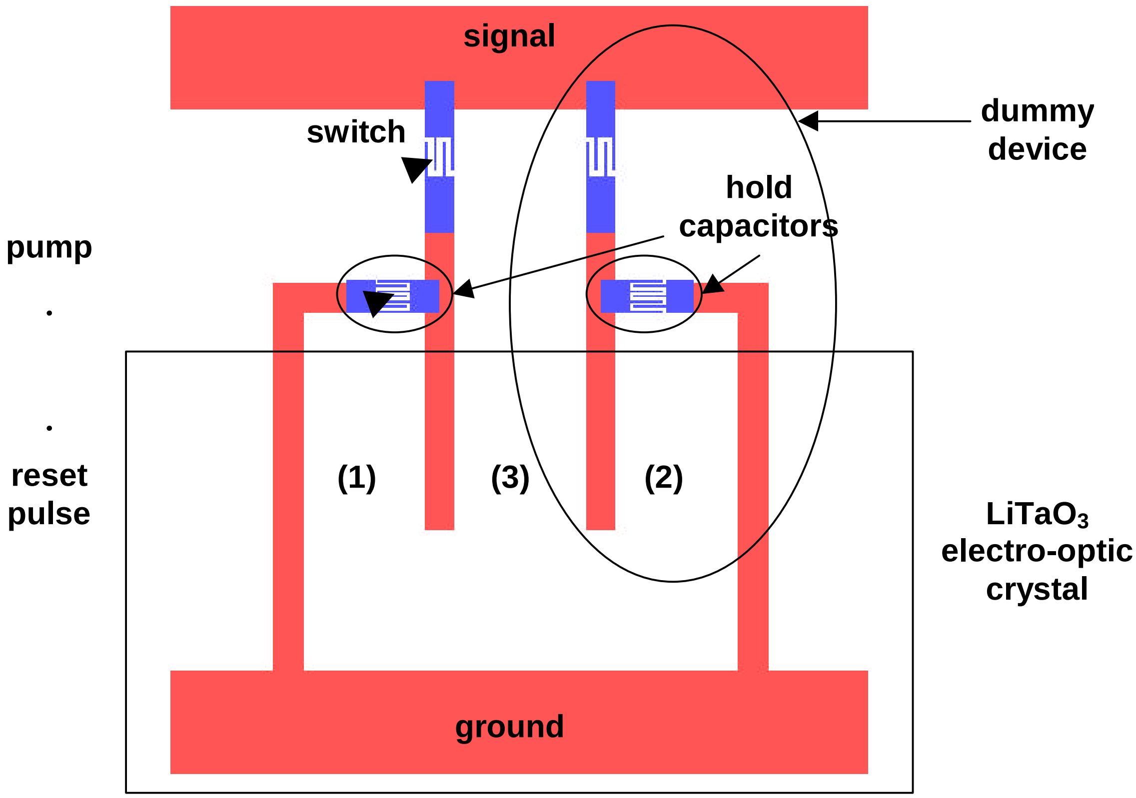


Fig. 2. Differential sample and hold test pattern. Numbers indicate position of probe light for corresponding curves in Fig. 3.

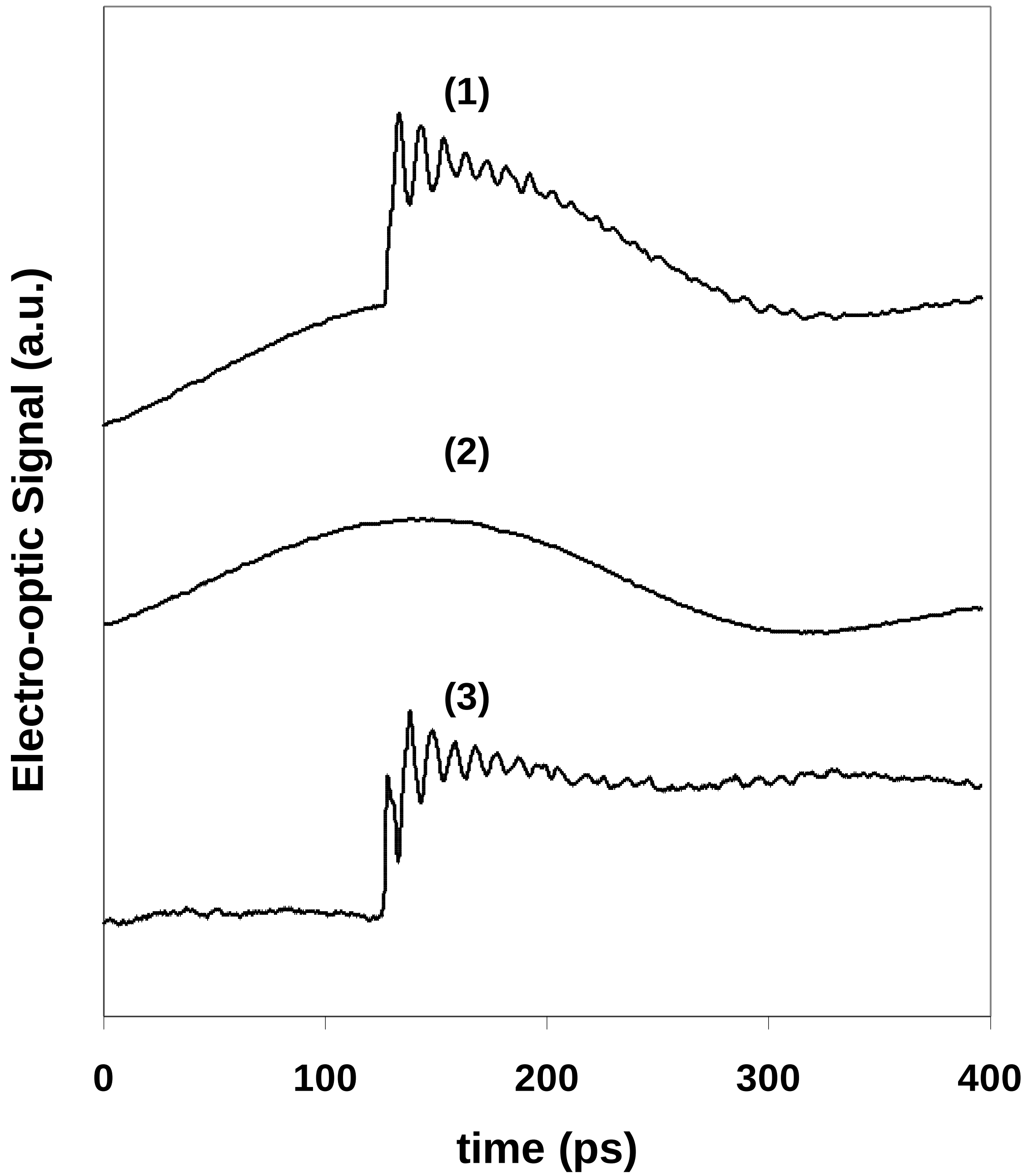


Fig. 3. Electro-optic sampling measurement results for differential sample and hold test circuit. Numbers indicate data for corresponding probe light positions in Fig. 2. (1) Feedthrough plus held voltage. (2) Feedthrough only. (3) Held voltage with reduced feedthrough.

Figure 2 shows the differential sample and hold test circuit. The symmetry of the device makes the feedthrough equal on both hold capacitors. The sample and hold is performed on the left side of the pattern, while the right side of the pattern serves as a dummy device which tracks the feedthrough voltage. By taking the differential signal between the hold capacitor voltages, the feedthrough is cancelled out. We demonstrate this scheme by measuring the voltages across each hold capacitor as well as the differential voltage between them as a function of time. For the measurement, the hold capacitance on the left side is reset using a pulse train synchronized to the pump and probe. Placement of the probe pulse for each voltage measurement, along with the corresponding output signal are shown in Figs. 2 and 3, respectively. The bottom signal (Fig. 3) clearly indicates a reduction in the feedthrough noise.

In summary, we successfully demonstrate the cancellation of feedthrough noise using a differential sample and hold circuit with LT GaAs MSM switches. The circuit achieves a sampling gate width of less than 2 ps. We believe this circuit is a promising candidate for use in future high speed photonic A/D conversion systems.

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