High-speed lithium tantalate-based silicon photonic modulators

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Thin-film lithium niobate (TFLN) has emerged as a leading material for integrated photonics, offering a unique combination of low optical loss and a strong, fast electro-optic (EO) coefficient, enabling high-speed modulation bandwidths exceeding 100 GHz [1,2]. More recently, thin-film lithium tantalate (TFLT) has gained attention for its enhanced stability and resistance to optical damage [3,4]. However, lithium contamination poses a challenge for CMOS compatibility. Here we present a heterogeneously integrated LT-based silicon (Si) Mach-Zehnder modulator (MZM) with competitive characteristics, compared to devices using monolithic TFLT-on-insulator technology.

The device consists out of a hybrid SiN/LT MZM. The LT is integrated on the Si photonic chip designed with a standard process design kit (PDK). The back-end integration of the LT is performed using micro-transfer printing. A schematic and a microscope picture of the device are depicted in Fig.1.a. and b. The coupling from the Si photonic circuit to the hybrid SiN/LT section is achieved with a vertical adiabatic coupler. The insertion loss, corresponding to the Si to SiN/LT transitions at each side of the phase shifter, and the propagation in the 7-mm-long arm are measured to be 2.9 dB in total. The modulator achieves a low half-wave voltage ($V\pi$) of 3.5 V, measured in a quasi-DC experiment, for a push-pull configuration. The operation bandwidth beyond 70 GHz is recorded with a vector network analyzer (VNA) and a fast photodiode. The measurement of the electrical-optical-electrical (EOE) response is presented in Fig.1.c. As a demonstration, the device is used in a data transmission link. The transmitted data is generated with an arbitrary wave generator (AWG) and recorded by a sampling oscilloscope after detection in a photodiode. Examples of eye diagrams with a symbol rate of 112 Gbaud in non-return-to-zero (NRZ) and pulse-amplitude modulation 4-level (PAM4) formats are shown in Fig. 1.d.

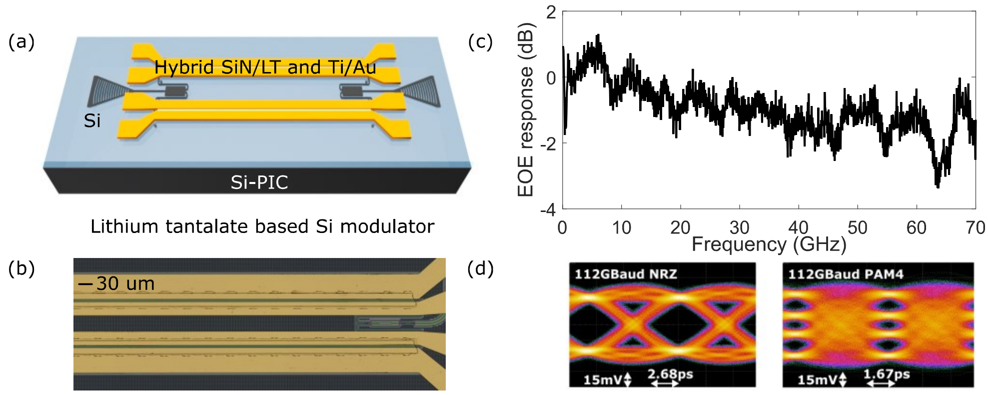

Fig. 1 (a) Schematic of a LT based Si modulator. (b) Optical microscope picture of the device. (c) High-speed response of the device. (d) Example of eye diagrams recorded in a data transmission link.

In conclusion, we have demonstrated the fabrication and characterization of a LT-based Si photonic modulator, exhibiting competitive performances. These results pave the way for power- and cost-effective, high-speed photonic applications, such as data communications, while ensuring seamless compatibility with standard silicon photonic platforms suitable for volume production.

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