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A dual-tone light source for terahertz transmitters on thin film lithium niobate

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Abstract: This work presents a dual-tone source on thin film lithium niobate for generating a tunable carrier frequency at the terahertz domain. The system exhibits stable carrier generation above 100 GHz with sub-kHz linewidth and tunability of over 5 GHz.

1. Introduction

Fast and high-bandwidth transceivers are critical components to address the exponentially growing demand for faster data transmission. The next generation of wireless communication networks requires data transmission rates of terabits per second which inevitably extends the carrier frequencies to the terahertz (THz) spectral region [1]. In addition to performance, there has been a great deal of interest in the community towards realizing compact, cost-efficient, and scalable transceivers. Nowadays, various integrated photonic platforms can provide chip-scale solutions for telecommunication technologies with the potential to achieve high data rates at THz frequencies [2]. Over the past decade, thin-film lithium niobate (TFLN) has emerged as an appealing platform with strong nonlinearity, ideal for high-speed modulation and frequency conversion [3]. TFLN offers a wide transparency window, ultra-low propagation loss, large electro-optic coefficient, and large modulation bandwidth for ultrahigh-speed optical modulation; however, the TFLN platform lacks monolithic light sources. Integration of III-V photonic components on TFLN has been proposed [5] and shown promising results, paving the way towards fully integrated photonic transceivers. A dual-wavelength source is a key component in a photonic-based THz transmitter [6]. The generated signal from such a source (two optical tones with a frequency difference f_c) is injected into a photomixer, where the two tones interfere with each other, resulting in a carrier signal at f_c in the THz region. This work demonstrates an on-chip dual-wavelength source on the TFLN platform using a single laser source. The advantages of such dual-tone sources compared to those employing two free-running laser sources are higher stability and lower cost.

2. Results

Our dual-tone source consists of a phase modulator and a ring filter fabricated on commercial 600 nm X-cut TFLN on insulator wafers. More details about the sample can be found in reference [4]. A continuous-wave 1550 nm laser is coupled to the chip via edge coupling through lensed fibers. The generated dual-tone signal is then amplified and injected into a commercial photomixer to produce a carrier signal in the sub-terahertz region. This emitted signal is collected using a horn antenna, downconverted, and sent to a real-time spectrum analyzer. Fig. 1a represents the setup for characterizing the carrier frequency generated by photomixing the dual-tone signal from our chip or two free-running lasers. For generating the tones, we employed a ring filter with a free spectral range (FSR) of 68 GHz and a 20 dB extinction ratio (Fig. 1b and 1c) after a phase modulator. The phase modulator was driven with a modulation frequency equal to half of the FSR value. Fig. 1d shows the filtered phase modulated signal at the drop port of the ring filter (before amplification). The carrier signal from our dual-tone generator chip, at $f_c = 136$ GHz, exhibits a stable signal with a linewidth of less than 1 kHz, while the signal generated from two free-running lasers drifts $\sim$20 MHz. Using a pre-amplifier before the photomixer, the detected signal shows a dynamic range of 32 dB after 10 dB of pre-amplification and 44 dB after 20 dB of pre-amplification (Fig. 1e). The signal can be tuned more than 5 GHz (4% of the carrier frequency). The tunability of the carrier frequency depends on the modulation frequency and the loaded quality factor of the ring filter.

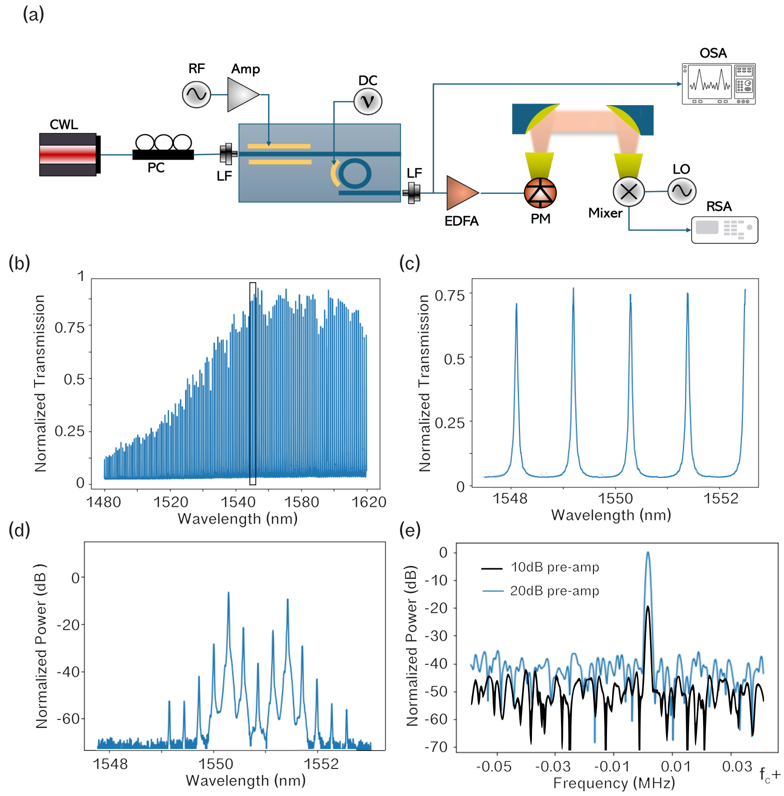

Fig. 1. (a) Measurement Setup. CWL: Continuous Wave Laser, PC: Polarization Controller, LF: Lensed Fiber, EDFA: Erbium Doped Fiber Amplifier, Amp: Amplifier, PM: Photomixer, LO: Local Oscillator, OSA: Optical Spectrum Analyzer, RSA: Real-time Spectrum Analyzer. (b) The transmission spectrum of the ring filter (drop port). Panel (c) is a magnified spectrum of panel (b), (d) The signal collected with the lensed fiber before EDFA, (e) Generated carrier frequency (f_c = 136 GHz) on real-time spectrum analyzer.

3. Conclusion

We have successfully demonstrated a compact, stable, and tunable dual-tone light source on the TFLN platform for generating a THz carrier frequency. This solution offers significant advantages in terms of stability and cost-efficiency over systems using two free-running lasers. Combining this dual-tone source with on-chip photomixing on the TFLN platform [7] enables the realization of a monolithic terahertz transmitter on TFLN.

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