Spur-Free Dynamic Range Measurements of the Light-Emitting Transistor

PL.Lam,[1,2] J.M.Dallesasse,[1] G.Walter[2]

1. Department of Electrical and Computer Engineering, University of Illinois at Urbana-Champaign, Urbana, IL, 61801 USA
2. Quantum Electro Opto Systems Sdn Bhd. Melaka, Malaysia

Email: plam5@illinois.edu (+1-217-9792690)

Introduction

Photonic devices are commonly used in digital transmission over fiber optic cables but the ability to transmit analog signals is also of interest for a growing range of applications. The market for analog optical links has experienced steady growth over the past 15 years for many application such as RF-over-fiber, analog links for cable television (CATV) signals, and military markets. The need to expand network capacity has also led to the exploration of advanced modulation formats that put further demands on device performance. Among the criteria for good analog links are low relative intensity noise (RIN) and high spur free dynamic range (SFDR). This abstract provides the first report of the Spur Free Dynamic Range (SFDR) of Light Emitting Transistors (LETs). The LET, invented in 2004 by Holonyak and Feng, came from recognition that transistor base recombination in a direct-gap material generates light related to the applied signal.[1,2] The transistor laser (TL), a laser version of the LET, has shown superior low relative intensity noise (-151 dB/Hz) at frequency 8.6GHz.[3]

Purpose

The goal of this work is to investigate LET spur free dynamic range for potential use in microwave analog optical links. We have performed LET SFDR measurements at different base currents to study the optimum bias condition for highest dynamic range. The highest reported SFDR (IM3) for an edge-emitting distributed feedback (DFB) laser emitting at 1.3μm is 100dBHz$^{2/3}$ for frequencies below 1GHz[4] and for a vertical cavity surface emitting (VCSEL) laser emitting at 850nm is 113dB-Hz$^{2/3}$.[5] For 1550nmVSCELs, the highest IMD3 SFDR reported is 81dB-Hz$^{2/3}$.[6] The highest SFDR of an LED reported to date is 39dB at 100MHz using single tone measurement.[7] This work shows that LETs have significantly better SFDR performance than LEDs, and similar performance to 1550nm VCSELs.

What specific results were obtained?

SFDR is measured on the LET and reported for the first time. LET design and bias considerations affecting SFDR are also examined.

Methodology and Results

The Agilent PNA-X is used to generate the two-tone signal at 0.995GHz and 1.005GHz and modulate the base of the LET. The second order (IM2) and third order (IM3) harmonics on the optical output are characterized. At a base current *(I_B)* of 3mA, we measured a SFDR (IM2) of 71.74 dB-Hz$^{2/3}$ and a SFDR (IM3) of 83.7 dB-Hz$^{2/3}$ as shown in Figure 2. We also observed that the spur free dynamic range of the LET increases linearly with bias as shown in Figure 3 and tabulated in Table 1.

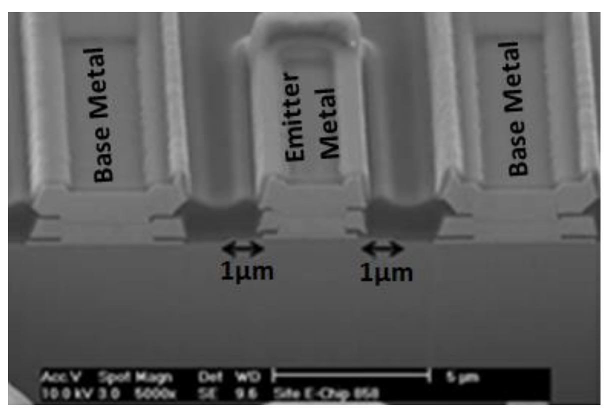

Figure 1: Scanning electron microscope photomicrograph showing the cross section of the LET.

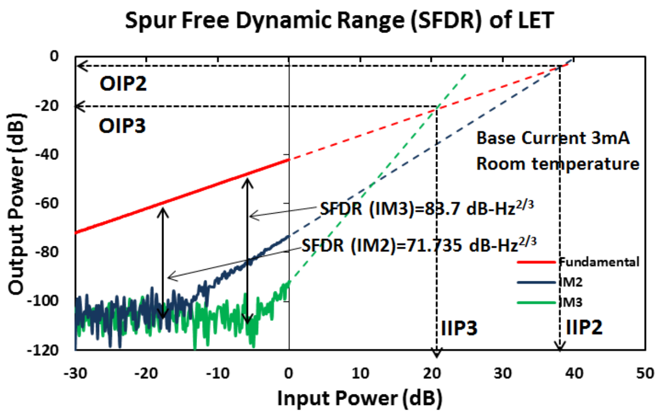

Figure 2: (a) Two tone 0.995 and 1.005GHz spur free dynamic (SFDR) measurement of LET at base current bias (I_B) 3mA.

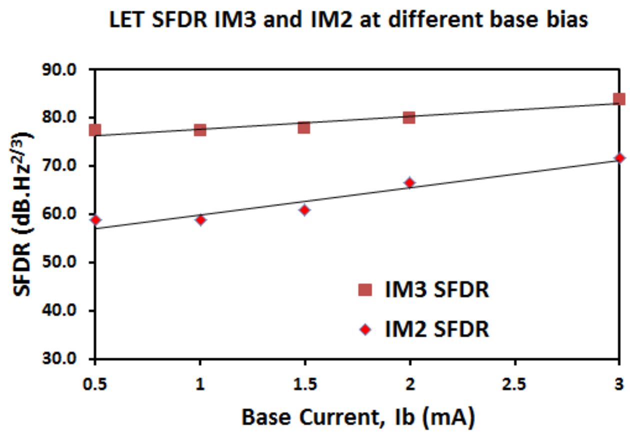

Figure 3: SFDR for IM3 and IM2 of LET at different base current bias *(I_B)*.

Table 1: Summary of light emitting transistor (LET) dynamic range characteristic

Base Current (mA)	SFDR (IM2) (dB-Hz$^{2/3}$)	SFDR (IM3) (dB-Hz$^{2/3}$)	IIP3 (dB)	OIP3 (dB)	IIP2 (dB)	OIP2 (dB)
0.5	58.84	77.4	11.0	-34.4	12.7	-32.9
1.0	58.85	77.2	10.8	-30.5	12.7	-28.7
1.5	60.94	77.8	11.6	-29.4	16.8	-24.4
2.0	66.44	79.8	14.8	-26.2	27.8	-13.3
3.0	71.74	83.7	20.6	-21.5	38.5	-3.6

Advancement of Compound Semiconductor Technology

Key Findings:

a) The SFDR of the LET shows an ~30dB improvement in performance relative to a conventional light-emitting diode. This is significant, as both devices utilize spontaneous emission.

b) The LET does not require complex driver circuitry and yet is able to achieve high dynamic range. It is potentially suitable for low cost short haul analog fiber links.

c) The LET has low power consumption compared to laser-based links, even those based upon VCSELs. Additionally, the LET can be directly driven – further reducing power dissipation.

REFERENCES

1. M. Feng, N. Holonyak, Jr., and R. Chan, Appl. Phys. Lett. **84**, (2004).
2. M. Feng, N. Holonyak, Jr., G. Walter, and R. Chan, Appl. Phys. Lett. **87**, 131103, (2005).
3. F. Tan, R. Bambery, M. Feng and N. Holonyak Jr.,Appl. Phys. Lett. **101**, 151118 (2012)
4. Pappert,S., Sun, C., Orazi,R and Weiner, T., Proc 2000 IEEE Int. Conf. Phased Array Systems and Technology, Dana Point, CA, USA, pp345-348
5. Lee, H.L.T, Dalai, R.V., Ram, RJ, and Choquette, KD., IEEE Photonic Technol. Lett., 1999, **11**, (11), pp.1473-1475.
6. Piprek, J., Takiguchi, K., Black, K.A., Hu, E.L., and Bowers, JE., IEEE Photonics Technol. Lett., 2000, **12**, (12), pp. 1686-1688.
7. Linning Peng, Sylvain Haese, and Maryline Hélard, IEEE Photonic Technol. Lett., 2013, **25**, (20), pp.2022-2025.