Synchronization and Chaos in a Laser Diode driven by a Resonant Tunneling Diode

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Resonant tunneling diodes (RTDs) have attracted a lot of attention due to their strong nonlinear current-voltage (*I-V*) characteristic, wide-bandwidth negative differential resistance (NDR) region, and inherent high frequency operation [1]. This paper presents a hybrid optoelectronic integrated circuit (OEIC) consisting of a RTD driving an optical communication laser diode (LD) that can produce various optical outputs including self-sustained oscillation, synchronization - including frequency division - and chaotic behavior. The circuit preserves the nonlinear dynamical behavior of the RTD increases laser diode functionality with several potential advantages, such as low modulating voltage, ultrahigh speed operation, and significant reduction in the complexity of chaotic optical carriers generators needed in optical communication systems [2]. A detailed description of the RTD-LD circuit can be found in [3]. Frequency division in a hybrid optoelectronic integrated RTD-LD circuit has been investigated theoretically and experimentally, Fig. 1.

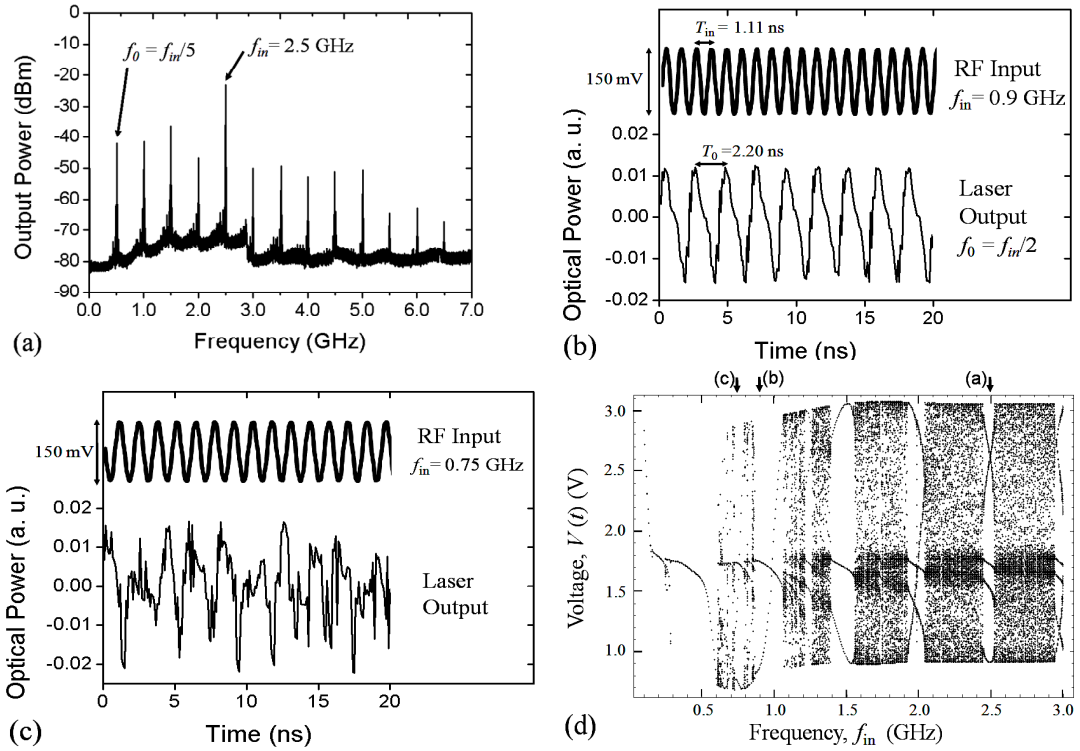

Fig. 1. Experimental laser outputs when RF signals $V_{in}(t)=V_{AC}\sin(2\pi f_{in}t)$ are applied: (a) Experimental spectrum of the laser optical output showing frequency division by 5 when V_{AC}=150 mV and f_{in}=2.5 GHz; (b) Laser output showing frequency division by 2: V_{AC}=150 mV at 0.9 GHz; (c) Laser output unlocked oscillations: V_{AC}=150 mV at 0.75 GHz. (d) Calculated bifurcation diagram for V_{AC}=150 mV at up to 3 GHz.

The potential applications of this RTD-LD circuit include clock recovery for direct data encoding using small perturbation signals to control the RTD-LD, and optical communication systems using chaotic waveforms, reducing the complexity of chaotic optical carrier generators.

[1] K. Maezawa, *A New Generation of Negative-Resistance Devices—New Developments in Ultrahigh-Frequency Applications Based on Resonant Tunneling Elements*, Electronics and Communications in Japan, Part 2 89, 29 (2006).
[2] A. Argyris, *et al.*, *Chaos-based communications at high bit rates using commercial fibre-optic links*, Nature 438, 343 (2005).
[3] T. Slight and C. N. Ironside, *Investigation into the Integration of a Resonant Tunnelling Diode and an Optical Communications Laser: Model and Experiment*, IEEE J. Quant. Elec. 43, 7, 580 (2007).