

# First experimental demonstration of a SOA/DFB-LD Feedback Scheme based all-optical flip-flop

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**Abstract:** Dynamic optical flip-flop operation is observed for the first time using a DFB laser diode connected with a SOA. Switching times of around 150ps for switch pulse energies of around 6pJ and a repetition rate of 500MHz have been measured.

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## 1. Introduction

As the network traffic load keeps on increasing, all-optical networks and more in particular packet or burst switched all-optical networks start to become a viable competitor to standard networks employing optical electronic optical (OEO) conversions [1]. In these packet switched optical networks there is a need for devices such as all-optical flip-flops (AOFFs) that show latching capabilities needed for packet header buffering and routing [2]. Previously we reported static bistable operation of a semiconductor optical amplifier (SOA) bidirectionally coupled to a distributed feedback laser diode (DFB-LD) [3]. In addition to that dynamic simulations showed that the device can also be used as an AOFF, i.e. can be set and reset using optical pulses [4]. Here we present for the first time experimental results on the dynamic behaviour of this new AOFF. Switching times of about 150ps, switch pulse energies of around 6pJ and a repetition rate of 500MHz were achieved.

## 2. Device description and measurement setup

The device used in our experiments is a DFB laser diode integrated on a single chip with a SOA and a coupler, as can be seen schematically in Fig. 1(a). Through the coupler a part (25%) of the output power of the SOA is coupled into the laser diode and at the same time a part (25%) of the laser power is coupled into the SOA. In this way a feedback scheme between laser diode and SOA is obtained [3]. On the device used there are in fact 4 LDs, but 3 of them are not used and therefore not shown in Fig. 1(a).

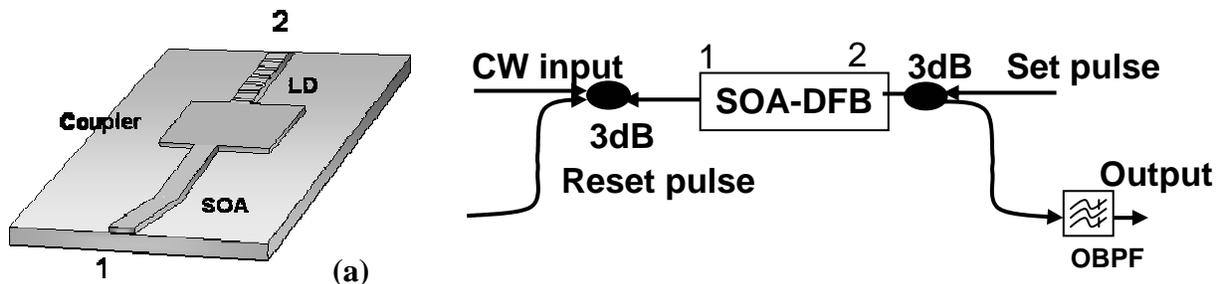


Fig.1. Schematic representation of (a) the integrated SOA/DFB laser diode feedback scheme and (b) the dynamic measurement set-up for the AOFF.

In Fig.1(b) the measurement setup used for the dynamic AOFF measurements is shown. A continuous wave (CW) signal is injected into the SOA (port 1), together with the reset pulse train. At the DFB-LD side of the device (port 2) the set pulse train is injected and also the DFB-LD's output power is measured there after passing through an optical bandpass filter (OBPF) to separate the laser signal from the CW and pulse signals.

## 3. Experimental results

In the experiments the CW signal and the set and reset pulses were at 1555nm while the DFB-LD operated at 1538.7nm. The drive current for the SOA was 103.5mA and for the DFB-LD 101.4mA. The CW input power was

4.4dBm but can be lower when the fibre to chip coupling is improved. The set and reset pulses had a length of 150ps and the pulse energy was 6.07pJ and 4.44pJ for the reset and set pulse respectively.

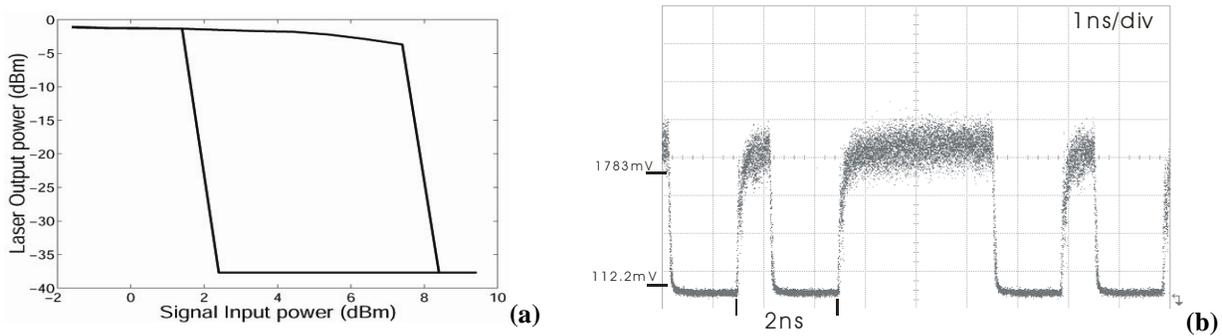


Fig. 2: (a) Measured static flip-flop characteristic and (b) dynamic flip-flop measurement.

In Fig. 2(a) the static flip-flop characteristic is shown. A contrast ratio of over 35dB can be observed. Fig.2(b) shows the dynamic operation of the AOFF. A contrast ratio of 12dB is obtained and one can also see that a pulse repetition rate of 500MHz can be used.

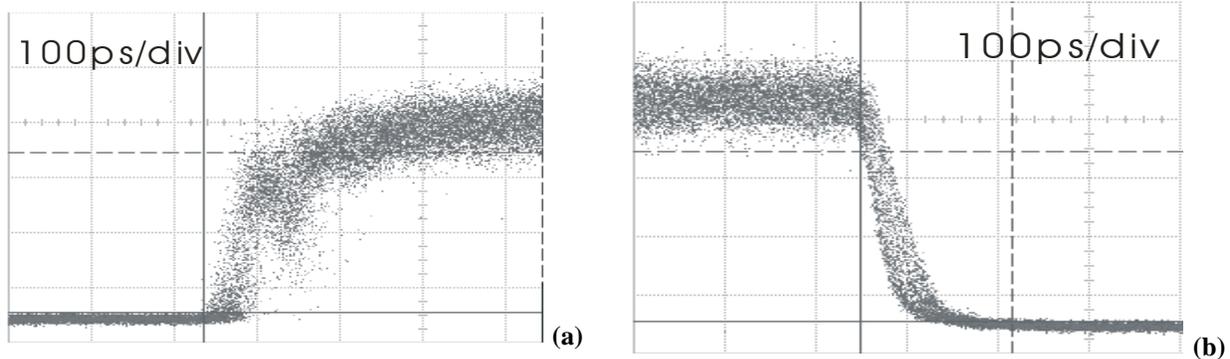


Fig. 3: (a) Measured rise time of the AOFF and (b) Measured fall time of the AOFF .

In Fig.3(a) and (b) the rise and fall time of the AOFF are shown. It can be seen that switching times of the order of 150ps can be obtained for both the switch-off and switch-on response.

#### 4. Conclusion

We have shown for the first time dynamic flip-flop operation using a SOA-DFB-LD feedback scheme. Using switch pulses of 150ps long with switch pulse energies of about 6pJ switching times of around 150ps and a contrast ratio of 12dB could be obtained. A pulse repetition rate of 500MHz has also been demonstrated.

#### 5. References

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