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Novel CW measurement of amplitude and phase transfer functions of opto electronic devices

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Abstract: We present a new and simple technique for measuring simultaneously the amplitude and phase transfer functions of semiconductor devices. These data allow us to calculate the linewidth enhancement factor, α, and first results are shown.

OCIS codes: (060.4080) Modulation; (250.5980) Semiconductor optical amplifiers

The relationship between the changes in the real and imaginary part of the complex susceptibility of a semiconductor material, often described by the linewidth enhancement factor or α-parameter, has dramatic influence on the properties of opto electronic devices. For lasers and electro absorption modulators (EAM) a non-zero α-parameter leads to linewidth broadening and chirp of the output pulses. For semiconductor optical amplifiers (SOA) a strong correlation between gain and refractive index results in additional signal noise when the amplifier is used for cross gain or cross phase signal processing.

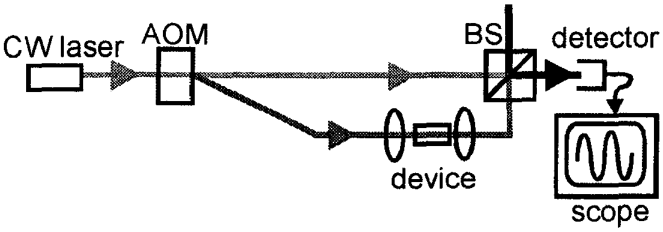

Fig. 1. Schematic of the experimental setup.

We present a novel and simplified technique that allows us to measure the amplitude and phase transfer functions of SOAs or EAMs using a CW laser and from the transfer functions extract the α-parameter. Fig. 1 shows the experimental setup, which can be summarized as follows: A 40 MHz acousto-optical modulator (AOM) splits a CW laser beam into two beams with a 40 MHz frequency difference. One of the beams is directed through the device and the output beam is then superimposed with the reference beam using a beam splitter (BS) and the resulting beat signal is detected. Phase and amplitude of the beat pattern on the detector is recorded as function of current in the device. Earlier techniques for measuring the α-parameter have been more complicated or have not given the full intensity and phase transfer functions [1-2]. The application of a CW laser source represents a considerable simplification compared to the work of Romstad *et al.* [3] who used a similar setup, but with a pulsed laser source.

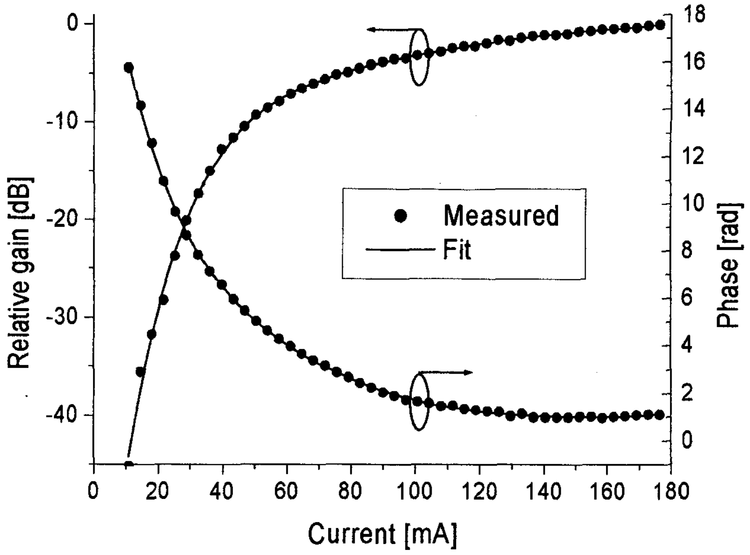

Fig. 2. Intensity and phase transfer functions.

First measurements have been done on a bulk SOA (JDS-Uniphase) at a wavelength of 1540 nm corresponding to the peak of its gain spectrum. The intensity and phase transfer functions are shown in Fig. 2 together with 5th order polynomial fits. We see a rapid increase of gain followed by saturation at 50 mA. The phase changes in a similar manner. The change of sign in the slope of the phase transfer function at 150 mA is ascribed to heating of the sample.

The alpha parameter, $\alpha(I)$ of the device, is calculated from the gain $g(I)$ and phase $\phi(I)$ transfer functions as [4]

$$\alpha = -2\frac{d\phi / dI}{d(\ln(g))/dI}, \tag{1}$$

and the result is shown in Fig. 3. The change in sign of the α-parameter at high currents owes again to temperature effects and is not expected in the case of active cooling. The magnitude of the α-parameter corresponds well with the results of other more complicated approaches [1-3].

In conclusion we report on a new and simple approach to measuring the complex transfer functions of some semiconductor devices. We will show results on different types of devices and at different wavelengths.

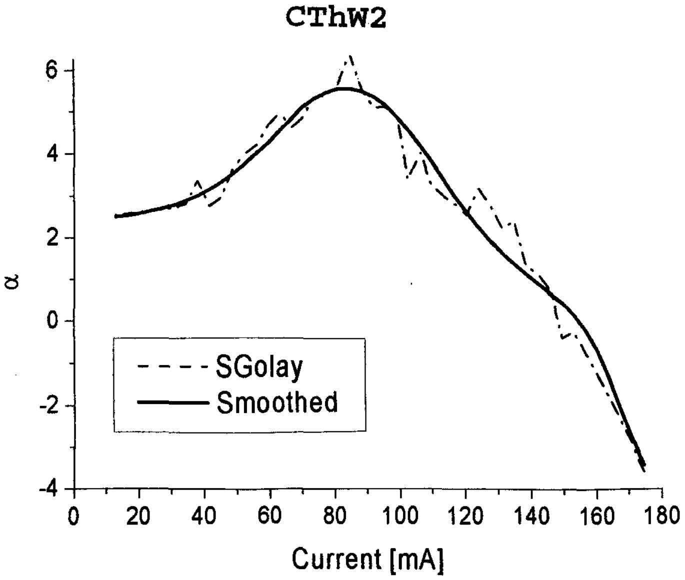

Fig 3. Derivation of α-parameter from transfer curves in Fig. 2 based upon polynomial fit (solid line) and Savitsky-Golay filtering (dashed).

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