InP-based Optical Waveguide Isolator

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Optical isolators are indispensable for protecting laser sources from optical feedback. We are studying an optical isolator concept that holds the promise of monolithic integration with III-V semiconductor active components.[1-2] Lateral magnetization of the metal contact of a semiconductor optical amplifier (SOA) induces a complex non-reciprocal shift of the effective index of TM-polarized guided modes, provided the metal is close (° 400nm) to the active region. The source of this non-reciprocal effect is the magneto-optical (MO) Kerr effect. The remaining loss in the forward propagation direction can be compensated through electrical pumping of the active material. The result is a component which, being transparent in one while providing loss in the opposite direction, is isolating. This operation principle is illustrated in Figure 1. The major advantage of this approach is that the isolator basically has the same structure as the laser it is to be integrated with, making monolithic integration possible.

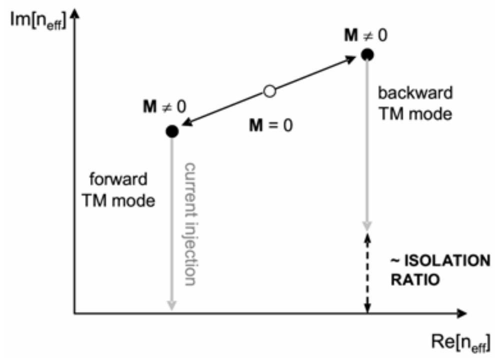

Figure 1: operation principle of the InP-based optical waveguide isolator

In order to provide the high TM-selective gain needed to compensate the modal loss in the forward propagation direction, a novel AlGaInAs/InP multi-quantum well active structure has been developed. Built-in tensile strain realizes TM-polarized material gain, while suppressing TE-gain. At the operation wavelength of 1.3µm, the AlGaInAs/InP material system is known to have considerably better gain performance than the conventional InGaAsP/InP material system. The metal contact is a $Co_{50}Fe_{50}$ film, on which a strong MO effect has been demonstrated.

In the most fundamental characterization method, transmitted optical powers for magnetization in both lateral directions are compared – switching the magnetization is equivalent to switching between forward and backward propagation direction. As such a transmission measurement is rather laborious, not suited for a first characterization of the devices, an alternative method has been developed. In case no anti-reflection coating is deposited on the cleaved facets, the device can be considered as a non-reciprocal semiconductor laser. In the above-threshold regime the isolation ratio depends only on the ratio of forward to backward emitted power and on the cavity length. The experimental optical power ratio of 1.8 (Figure 2) corresponds to an isolation ratio of 104dB/cm. The internal loss can be completely compensated by moderate current injection, as can be deduced from the experimental threshold current of 250mA – the threshold current provides an upper limit on the transparency current.

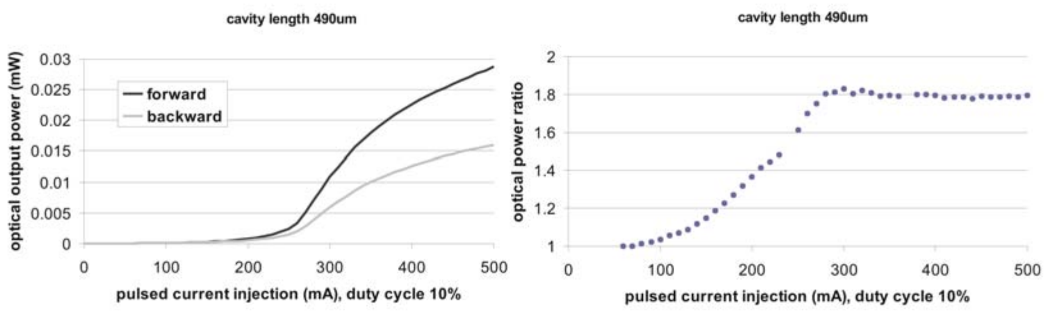

Figure 2: isolation ratio extraction based on non-reciprocal lasing; optical output power for both propagation directions (left) and optical power ratio (right).

[1] M. Takenaka, and Y. Nakano, "Proposal of a Novel Semiconductor Optical Waveguide Isolator", in Proc. 11th Int. Conf. on Indium Phosphide and Related Materials (Institute of Electrical and Electronics Engineers, New York, 1999), pp.289-292.

[2] M. Vanwolleghem, W. Van Parys, D. Van Thourhout, R. Baets, F. Lelarge, O. Gauthier-Lafaye, B. Thedrez, R. Wirix-Speetjens, and L. Lagae, "Experimental demonstration of nonreciprocal amplified spontaneous emission in a CoFe clad semiconductor optical amplifier for use as an integrated optical isolator", APL **85**, 3980-3982 (2004).