Demonstration of a Novel Integrated Isolator Concept

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The development of a waveguide-type optical isolator continues since more than 20 years. In 1999 a new concept for an integrated optical isolator was theoretically proposed[1]. The component basically is a semiconductor optical amplifier (SOA) covered with a transversally magnetized ferromagnetic metal very close (in the order of 300nm) to the active region (fig 1). The presence of the magnetized ferromagnetic metal causes non-reciprocal absorption of the TM-guided mode, while the active region compensates the optical loss in the forward propagation direction. The metal layer also serves as the electrical contact for the underlying SOA. The outcome is a component, which is transparent in the forward and absorbing in the backward propagation direction. The device is easily integrable with a semiconductor laser, as it is basically the same structure. First, we discuss the electrical optimization of the component. In a second part, the first demonstration of the working principle is presented. The material system under study is InGaAsP/InP.

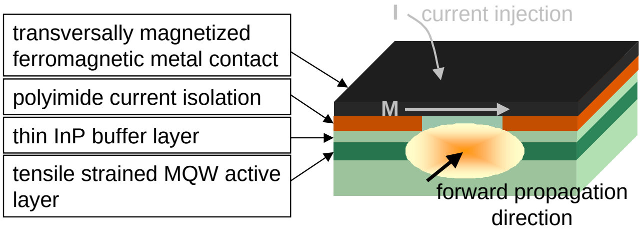

Fig 1 device structure of the novel integrable isolator

For a good performance of the component, a metal-semiconductor contact structure had to be designed with both a low contact resistivity and low absorption of the semiconductor layer at the operation wavelength of 1.3µm. This implies that the standard contact material, InGaAs, with absorption levels up to 10^4/cm, is not suitable. Four alternative contact schemes were thoroughly examined. The result is a contact structure with a contact resistivity of $10^{-5}\Omega cm^2$ with a minimal absorption. It consists of a 100nm thick InGaAsP(λ_g = 1.17µm) layer topped with a 15nm tick InGaAs layer with on top the sputtered ferromagnetic metal. Fast alloying at 350°C lowers the contact resistivity to $10^{-5}\Omega cm^2$.

This contact scheme is used in the first generation demonstrators. The ferromagnetic metal alloy is $Co_{90}Fe_{10}$. The active layer is an optimized InGaAsP-based tensile strained multi-quantum well structure. The devices were characterized by polarization selective detection of the amplified spontaneous emitted light (ASE), while looping the transverse magnetization of the metal between the saturation fields in both directions. After all, detection at one facet while switching the magnetization is equivalent with measuring at both facets with fixed magnetization, but it is much easier. The result is a power graph, which, for TM-polarization reflects the magnetization hysteresis of the metal (fig 2). The TE-response remains flat, as the TE-guided mode is not affected by the non-reciprocal effect. Quantitative evaluation shows an isolation ratio of 2dB/mm.

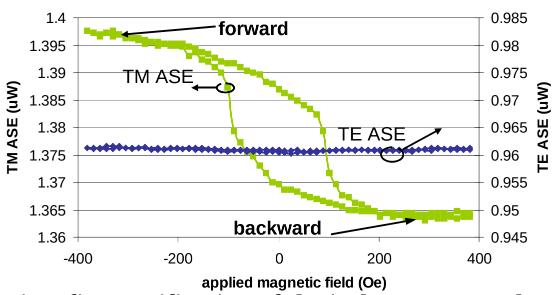

Fig 2 first verification of the isolator concept by polarization selective ASE-power

[1] M. Takena and Y. Nakano, "Proposal of a Novel Semiconductor Optical Waveguide Isolator", Proc. of the 11th International Conference on Indium Phosphide and Related Materials, May 1999, pp. 289-292.