Monolithic Highly Selective Long Wavelength Resonant Vertical-Cavity Enhanced Photodetector with Two InP/Air-Gap DBRs

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Wavelength division multiplexing (WDM) systems offer the possibility to increase the transmission capacity of optical fibre networks by carrying several channels simultaneously. Reconfiguration of the network and add and drop operations are considered to be an important feature to achieve high flexibility. Hence, new wavelength tunable devices operating at 1.55 µm are of high interest and the fabrication of tunable vertical-cavity devices is particularly interesting.[1] Considerable effort has been spent into the investigation and fabrication of tunable WDM filters and tunable vertical-cavity surface emitting lasers (VCSELs) whereas only few results for tunable or potentially tunable selective receivers have been reported so far. Resonant vertical-cavity enhanced (RVCE) photodetectors (PDs) have created much interest due their inherent features such as narrow spectral linewidth, easy coupling, and their potential use as high speed devices with high quantum efficiency.

Here we present a potentially tunable RVCE photodetector with two InP/air-gap distributed Bragg reflectors (DBRs). A similar approach has been recently presented by Huang[2] et al. using a two period InP/air-gap bottom DBR whereas the top DBR was formed by the semiconductor-air interface. This device exhibited a rather wide full width at half maximum (FWHM) of >30 nm due to a rather low reflectance of the top DBR. Our design implements a two period InP/air-gap top mirror to obtain a narrower FWHM suitable for WDM systems. The presence of the air-gaps provides for potentially tunable devices demonstrated for e.g. tunable filters.[3] The epitaxial structure has been grown by metal-organic vapour phase epitaxy (MOCVD) with growth conditions adapted for micro-mechanical structures.

Fig. 1 shows the design of the monolithic RVCE photodetector with two InP/air-gap DBRs and Fig. 2 the fabricated device. The top mirror InP plates are supported by SiN_x pillars necessary to allow a small active area and easy access to the electrical contacts of the PIN diode. The mesa has been patterned by reactive ion etching forming first the holes for the SiN_x pillars, the plates for the top mirror, the two levels for the p- and n-contact and finally the grooves for the bottom mirror. The InGaAs of the sacrificial layers has been selectively removed by a $FeCl_3/H_2O$ chemistry forming the air-gaps while the InGaAs layer of the PIN diode has been protected by resist. The devices have been dried using CO_2 critical point drying to avoid sticking of the membranes. Details of the process can be found elsewhere.[4]

Fig. 3 shows a preliminary optical spectrum of the fabricated RVCE photodetector. The full width half maximum (FWHM) of the main resonance is only 2 nm. The second and third order of the resonance can be seen as well due to the rather long cavity. Further optical and electrical characterisation will be carried out.

[1] B. Mukherjee, 'Optical Communication Networks', San Francisco, McGraw-Hill, 1997

[2] H. Huang, Y. Huang, X. Wang, Q. Wang, X. Ren, 'Long Wavelength Resonant Cavity Photodetector Based on InP/Air-Gap Bragg Reflectors'; IEEE Photonics Technology Letters, Vol. 16, No. 1, January 2004

[3] A. Spisser, R. Ledantec, C. Seassal, J.L. Leclercq, T. Benyattou, D. Rondi, R. Blondeau, G. Guillit, P. Viktorovitch, 'Highly selective and widely tunable 1.55-µm InP/air-gap micromachined Fabry-Perot filter for optical communications', IEEE Photon. Techn. Lett., Vol. 10, Sept. 1998

[4] N. Chitica, J. Daleiden, J. Bentell, J. André, M. Strassner, S. Greek, D. Pasquariello, M. Karlsson, R. Gupta, K. Hjort, 'Fabrication of Tunable InP/Air-gap Fabry-Pérot cavities by selective Etching of sacrificial InGaAs Layers', Physica Scripta, Vol. T79, 1999

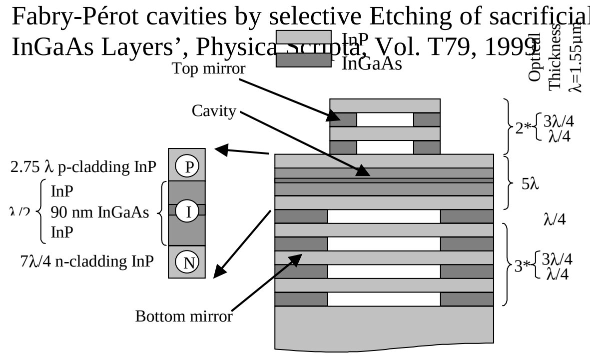

Fig. 1 Design of the RVCE photodetector

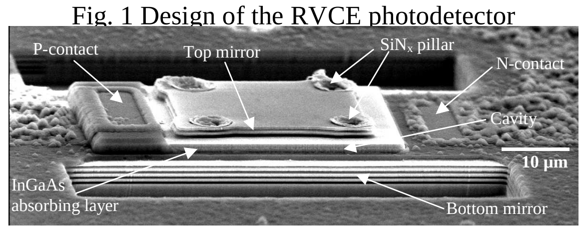

Fig. 2 SEM of the fabricated RVCE photodetector

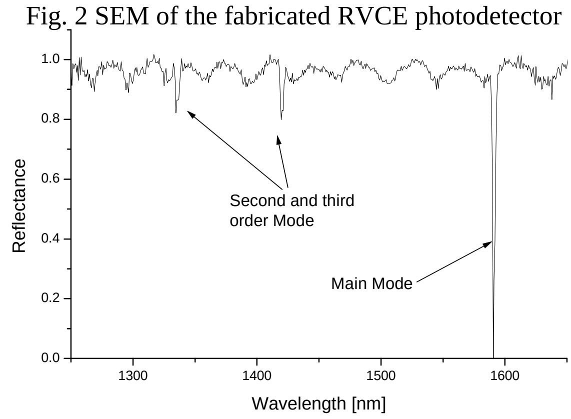

Fig. 3 Reflectance spectrum of the RVCE photodetector