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Integration of InP grating-based demux with p-i-n array for monolithic WDM detection

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ABSTRACT

We report an integrated wavelength demultiplexing grating spectrometer and p-i-n array for use in dense wavelength division multiplexing (WDM) applications. The single InP chip incorporates a novel waveguide/detector coupling scheme and is capable of demultiplexing up to 92 wavelength channels. Operation in the 1.5μm fiber band was successfully demonstrated with a channel spacing of 1nm. The detectors exhibited bandwidths of 15 GHz.

1.INTRODUCTION

Multi-wavelength architectures are being actively considered for high speed inter-office links, local loop applications, advanced wavelength routed networks, and computer interconnects. In dense (1-4nm spacing) direct detection systems, the separation of different wavelength signals is currently achieved through the use of bulk optical components. A grating-type demultiplexer is generally used to separate the different wavelength channels which are then detected by a hybrid-mounted detector array.

Integration of the dispersing grating and detector array on a single chip offers clear advantages. It eliminates multiple component optical assembly and results in automatic internal optical alignment. This holds the potential for cost reduction through increased reliability. In this paper we describe our recent realization of such a monolithic component. The InP based device uses an array of 92 p-i-n detector elements integrated with a single planar-waveguide-based wavelength demultiplexer. The complete device measures about 12 by 4mm. A 42 channel DEMUX detector with a channel spacing of 4nm has also been reported.[1]

2.DEVICE OPERATION

A schematic of the integrated WDM detector array is shown in Figure 1.[2] Waveguides etched into the InP/InGaAsP/InP planar material guide the incoming light signal to the demultiplexing body of the device. This light then spreads out in the planar waveguide portion according to the width of the input guide and is diffracted and refocussed back onto the output waveguides by the etched grating. These output guides then transmit the demultiplexed light to the waveguide p-i-n detectors. The focal distance from the grating structure to the waveguide detectors is 10mm and the lateral separation between output

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guides is 20μm. The grating operates in 16th order and separates signals at 1nm wavelength spacing in the 1.5μm fiber band.

3.DEVICE FABRICATION

The guide/detector layer structure is shown in Table 1. The epitaxial layers were first grown by MOCVD at a chamber pressure of ~76 Torr on a semi-insulating Fe:InP substrate. The wafer was then coated with oxide and detector mesa structures were defined by etching down to the InGaAsP waveguide core by a process of dry etching and then wet-chemical etching. The wafer was then returned to the OMCVD reactor for regrowth of an InP layer. This provided isolation, passivated the p-i-n diodes, and in addition formed an upper cladding layer to the planar waveguide.

Using an SiOx mask, the diffraction grating was etched through the waveguide structure by chemically assisted ion beam etching (chlorine reactive gas, 1500 V Xenon ions) and was metallized with Ti/Au to obtain high reflectivity. The waveguides were shallow-etched to achieve single moded behavior.

The detector fabrication was then completed by etching the down-stream half of the mesa down to the n-contact layer and then forming contact metallizations through a plasma deposited SiOx dielectric layer. Ti/Au was used for the p-contact and Ni/Ge/Au/Ni/Au for the n-contact. The waveguide/detector structure used is thus a hybrid between a conventional and vertical coupling approaches.[3] It combines the advantages of both techniques. The waveguide optical field is pulled up into the detector absortion layer and this results in strong attenuation of the incident waveguided light. Only short lengths of detector are thus needed to absorb all the incident waveguide light.

Following planarization with polyimide, a final Ti/Au metal was evaporated to form high speed probe compatible contacts to the detectors. Finally, the chip was thinned to 150μm and cleaved. The input facet perpendicular to the input waveguides was then anti-reflection coated with a single layer of SiOx. A schematic diagram of the device geometry and photomicrograph of the detector region at the central input waveguide is shown in Fig.1.

4.EXPERIMENTAL RESULTS

The wavelength demultiplexing behavior was monitored from the detector photocurrents. The WDM performance is illustrated in Fig.2 which plots the peak wavelength response for 30 channels. WDM detection was observed for all 92 channels although the relative response decreased below 3dB beyond the central 30-35 p-i-n detector region. Wavelength dispersed output is obtained from 1.515μm to 1.542μm at a channel spacing of a little less than 1nm.

The wavelength response of individual detectors indicated a channel passband of 6-8 Å. Some crosstalk was observed between the waveguides leading to the photodetectors, which limited nearest neighboring isolation to 6-8 dB. We note, however that our previous slightly modified passive grating demultiplexers have performed with - 20dB channel isolation[4] indicating that a low crosstalk for the DEMUX detector array should be attainable.

The output waveguides coupled to the p-i-n detectors used a novel coupling scheme. The 25μm long detectors used here were found to absorb 90% of the incident guided light. The detector capacitance was just 50fF. The high speed of response revealed a bandwidth of 15GHz (Fig.3), which was limited by high contact resistance of the n-type metallization.

5. CONCLUSION

We have demonstrated the integration of a compact grating spectrometer with a detector array for use in the long wavelength fiber band. A channel separation of 1nm was achieved. The fabrication process of the InP based chip used conventional photolithography, dry and wet chemical etching and is readily scalable to high volume manufacture.

6. ACKNOWLEDGMENT

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7. REFERENCES

1. C. Cremer et al., I.E.E.E. Phot. Tech. Lett., 4, 108, 1992.
2. J.B.D. Soole et al., Integrated Photonics Research meeting, Paper PD-1, New Orleans, LA, April, 1992.
3. J.B.D. Soole et al., O.S.A. Topical Meeting on Optoelectronics, Monterey, CA, July, 1990.
4. J.B.D. Soole et al., Appl. Phys. Lett., 58, 1949, 1991.

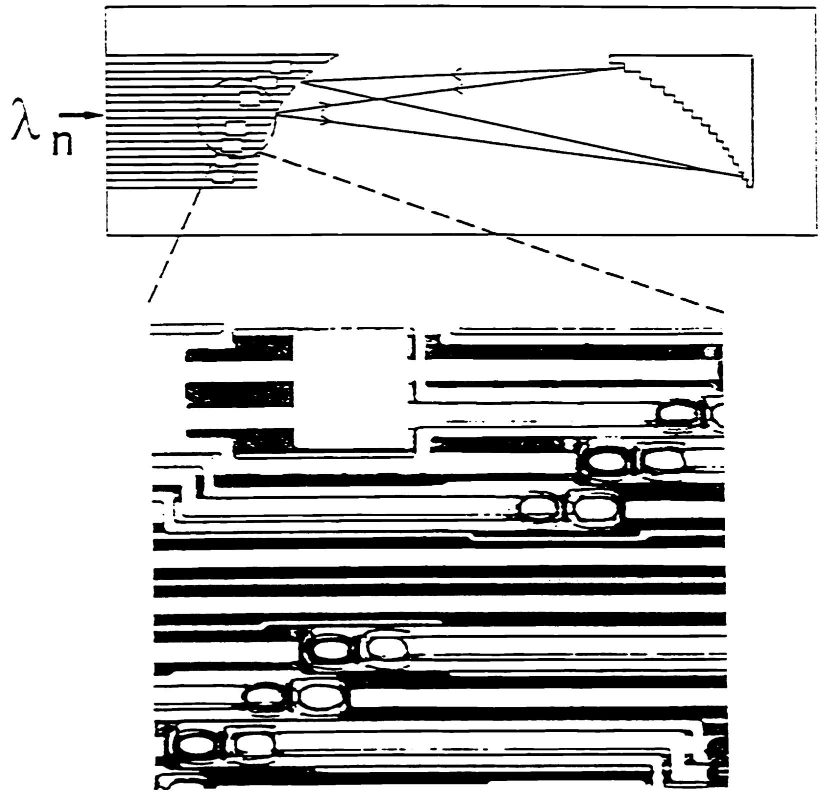

Figure 1. Schematic of the WDM detector chip, and micrograph of the central portion of the WDM array.

Layer	Material	Thickness	Doping
contact	p-InGaAs	0.1 μm	$5x10^{18}$
	p-InGaAsP (1.3μm)	0.4 μm	$1\text{-}5x10^{17}$
absorption	InGaAs	0.7 μm	
contact	n-InP	0.15 μm	$4x10^{18}$
guide	n-InGaAsP (1.1μm)	0.6 μm	
buffer	n-InP	0.5 μm	
	Semi-Insulating InP Substrate		

Table 1. Layer structure in the detector region

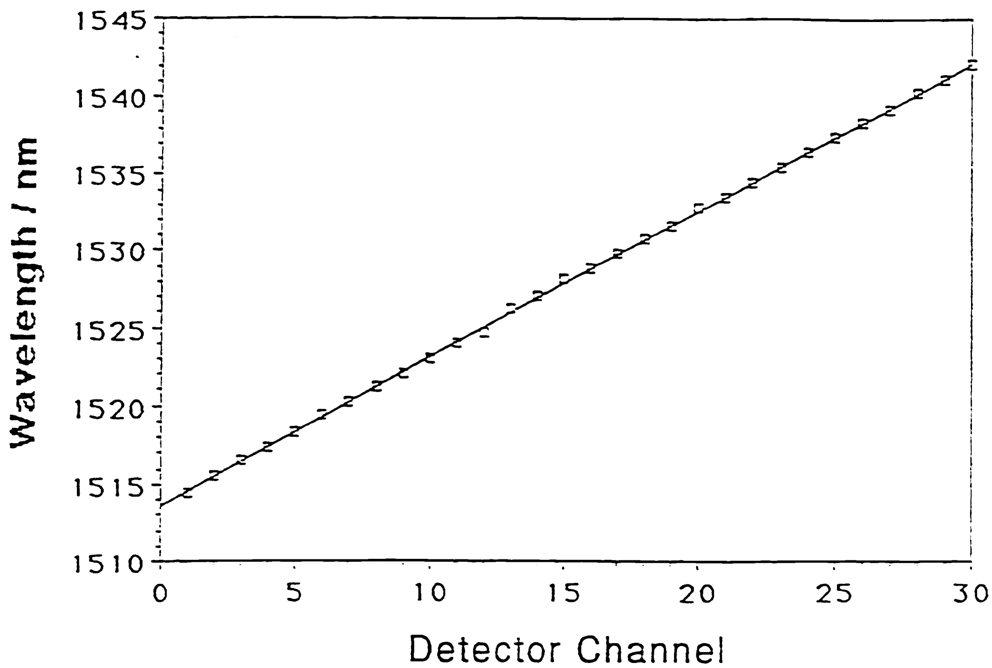

Figure 2. Response wavelength of the detectors.

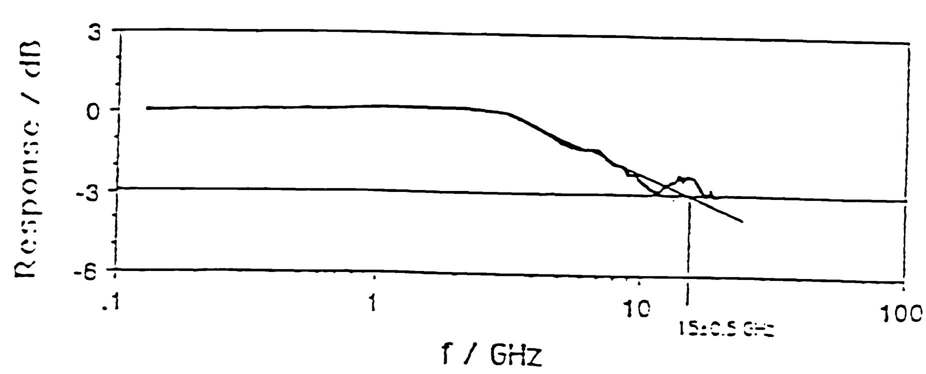

Figure 3. Frequency response of a waveguide detector.