Fabrication of a 1.3/1.55㎛ InGaAlAs/InP Dual Wavelength Demultiplexer Based on Multimode Interference(MMI)

다중모드 간섭효과를 이용한 1.3/1.55㎛ InGaAlAs/InP 파장분배기의 제작

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The wavelength demultiplexer is an essential component in optical transmission systems using wavelength-division multiplexing(WDM), which can increase the number of channels and information capacity of optical fibers. For optical telecommunication, much attention has been given to demultiplexing two wavelengths in the 1.3㎛ of low dispersion band and 1.55㎛ of low loss window. Various integrated-optical devices have been proposed to perform this function, including conventional directional couplers, asymmetric Y-branching devices, asymmetric Mach-Zehnder interferometers and two-mode interference devices. Especially, devices based on multimode interference(MMI) have found a growing interest in recent years because of their desirable characteristics, such as compact size, low excess loss, wide bandwidth, polarization independence, and relaxed fabrication tolerances[(1)]. The demultiplexers were all made by either ion-exchange in glass or silica-based material[(2),(3)]. III-V semiconductor-based devices have advantages over silica-based devices for monolithic integration with active components. In this study, we have designed 1.3/1.5㎛ InGaAlAs/InP MMI dual wavelength demultiplexers with strongly guided structure using the effective index method(EIM) and a finite difference beam propagation method(FD-BPM) simulation[(4)]. To make the device as short as possible, the paired-restricted interference scheme was used. A direct image is formed at the end of the MMI section for one wavelength while a mirrored image for the other wavelength. We fabricated them on InP materials by using an optimized CH_4/H_2 RIE and H_2SO_4:H_2O_2:H_2O wet etching processes.

Figure 1 shows a schematic diagram of the designed 1.3/1.5㎛ InGaAlAs/InP MMI dual wavelength demultiplexer. λ_1=1.3㎛ is in a cross-coupled state and λ_2=1.55㎛ is in a bar-coupled state. Figure 2 shows the results of FD-BPM simulation of the device at the ends of MMI section. The insertion loss of 0.49dB(0.62) and contrast of 25.4dB(26dB) was obtained at wavelength 1.55㎛ (1.3㎛) at the end of s-bends for TE polarization[(4)]. All the input and output waveguides were 2㎛ wide and supported the fundamental mode only. The epitaxial layer consisted of 800-nm-thick lattice-matched InGaAlAs layer cladded by a 1.5-㎛-thick InP layer and were grown by molecular beam epitaxy(MBE) on an InP substrate. For the fabricated devices, MMI was 16.65㎛ wide and 4985㎛ long, and the length and radius of s-bend are 1615㎛ and 2100㎛, respectively. Figure 3 shows SEM micrographs of a fabricated 1.3/1.5㎛ dual wavelength demultiplexer. For measurement setup, the light beams produced by a tunable laser source at 1.55㎛ and a FP laser diode at 1.3㎛ were focused on the cleaved facet of the input waveguide by means of a tapered fiber[5]. The image of the near-field pattern was monitored by an infrared(IR) camera. Figure 4 shows the near-field output spots at the end facets of the device with s-bend. To measure the performances of the device, an optical spectrum analyzer and an optical power meter were used. The measured insertion losses was 3.71dB(3.11dB) and the contrast was 18.6dB(16.67dB) at wavelength of 1.3㎛(1.55㎛). The measured insertion loss was higher than the simulated one, which could be ascribed to device process and measurement errors. Further improvements in device performances can be achieved by more precise control of the photolithography and the etching process.

In conclusions, we demonstrated theoretically and experimentally that an InGaAlAs/InP MMI dual wavelength demultiplexer with a strongly guided ridge structure have the advantage of ease in manufacture and can be used to demultiplex the wavelengths of 1.3㎛ and 1.5㎛ between the two split output ports.

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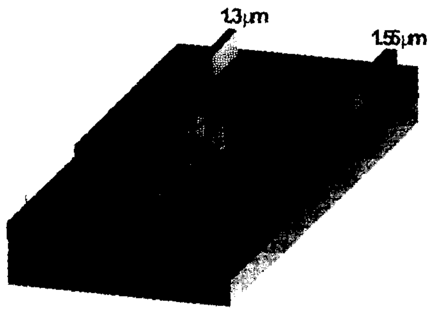

그림 1. Schematic diagram of the designed 1.3/1.5㎛ InGaAlAs/InP MMI dual wavelength demultiplexer.

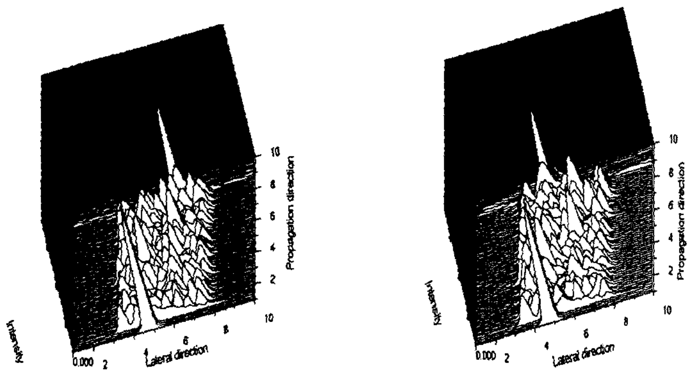

그림 2. Results of FD-BPM simulation of the device at the ends of MMI section

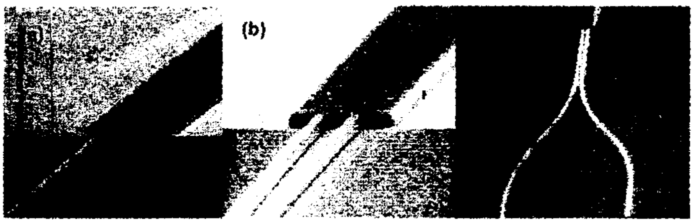

그림 3. SEM micrographs of a fabricated 1.3/1.5㎛ dual wavelength demultiplexer.

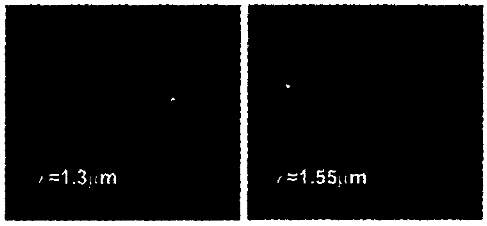

그림 4. Near-field output spots at the ends of s-bend.