CTuA2 Fig. 3. (a) Device schematic (b) Calculated reflectivity spectrum: green line is the device before oxidation. Blue line is the device after oxidation.

structures grown on nonplanar substrates. Further experimental results on devices will be presented at the time of the meeting.

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CTuA3

8:45 am

Multi-wavelength Infrared Detection Realized with Two Distinct Superlattices Separated by a Blocking Barrier

C.C. Chen, H.C. Chen, W.H. Hsieh and C.H. Kuan, Department of Electrical Engineering and Graduate Institute of Electronics Engineering, National Taiwan University, Taipei, Taiwan, R.O.C. 10617

S.D. Lin and C.P. Lee, Department of Electronic Engineering, National Chiao Tung University, Hsinchu, Taiwan, R.O.C. 30050

A detector with two distinct superlattices separated by a blocking barrier was investigated for multi-wavelength infrared detection. Figure 1

CTuA3 Fig. 1. The structure of the multi-wavelength infrared photodetector containing two superlattices and a separating barrier.

shows the band structure of our detector. It contains sequentially a 500 nm bottom contact layer, a 14-period bottom superlattice, a blocking barrier, another 14-period top superlattice, and a 400 nm top contact layer. Each period of the bottom and top superlattices is respectively composed of 6 nm GaAs well and 4 nm $\text{Al}_{0.27}\text{Ga}_{0.73}\text{As}$ barrier, and 4.5 nm GaAs well and 6 nm $\text{Al}_{0.31}\text{Ga}_{0.69}\text{As}$ barrier. The blocking barrier consists of a 60 nm $\text{Al}_{0.27}\text{Ga}_{0.73}\text{As}$ layer, a 50 nm graded $\text{Al}_x\text{Ga}_{1-x}\text{As}$ layer with x increasing from 0.27 to 0.31, and a 60 nm $\text{Al}_{0.31}\text{Ga}_{0.69}\text{As}$ layer. Both the contact layers and the superlattice wells are doped with $1 \times 10^{18} \text{ cm}^{-3}$ of Si. The blocking barrier and the superlattice barriers are left undoped.

The blocking barrier separating the two superlattices allows only the photoelectrons from one of the superlattices to be collected under either voltage polarities. At the same time, it serves as the energy filter for the photoelectrons. Accordingly, the photo-response is switchable between $7.5 \sim 12 \mu\text{m}$ and $6 \sim 8.5 \mu\text{m}$ by the bias polarity, and the spectral responsivity in each wavelength region is also tunable by the bias magnitude. The measured spectral responsivity at 30 K is shown in Fig. 2. The results are consistent with our design.

In addition, our detector exhibits advantages over the conventional multi-stack photodetector. These include little temperature dependence of the spectral responsivity and the same order of responsivity in the two wavelength regions. The measured peak responsivities in the two regions are 117 mA/W at $9.8 \mu\text{m}$ at 1 V and 129 mA/V at $7.4 \mu\text{m}$ at -0.8 V . Also, the detectivities are comparable with the conventional design. The zero background peak detectivities are $2.3 \times 10^{10} \text{ cmHz}^{0.5}/\text{W}$ at 50 K under 0.7 V with wavelength being $9.8 \mu\text{m}$, and $8.7 \times 10^{10} \text{ cmHz}^{0.5}/\text{W}$ at 70 K under -0.7 V with wavelength being $7.4 \mu\text{m}$. These characteristics show the structure is very

CTuA3 Fig. 2. The measured spectral responsivity at 30 K under several bias voltages.

suitable to realize multi-wavelength infrared photodetector.

CTuA4

9:00 am

A Bi-directional Optical Link Using a Stacked Thin Film Emitter and Detector

D.L. Geddis and N.M. Jokerst, School of Electrical and Computer Engineering, Georgia Institute of Technology, Atlanta, GA 30332-0250

With the push for more information at faster speeds to the home, there has been a push to replace wire cable with fiber cable. One architectural approach to fiber in the last mile is to separate data and broadcast to the home one two separate fibers. However, a third communication channel is necessary to transport data from the home. One approach to this problem is to utilize one of the fibers for incoming data and outgoing data. Thus, a method for single fiber bi-directional communication is necessary.

One method of realizing bi-directional communication utilizes emitters and detectors that are capable of transmitting and receiving into and out of a single fiber. This can be realized using a single device that can operate as both a photodetector and a light emitter, which compromises the performance of both devices. Another approach is to use two different devices, one for the light emitter and the other for the detector, and to use a splitter to couple light into and out of the detector and emitter, respectively. However, adding a splitter to the system increases the cost. In this paper, we demonstrate a fabrication method for stacking thin film emitters and detectors directly on top of one another to realize a bi-directional, co-located emitter/detector pair for bi-directional optical communication. To our knowledge, this is the first demonstration of the stacking of an emitter/detector pair of active components that are independently grown and optimized before integration.

To fabricate the bi-directional co-located optical link, a thin film GaAs-based inverted metal-semiconductor-metal (I-MSM) photodetector (PD) and a thin film GaAs-based light emitting diode (LED) have been independently grown, fabricated into devices, and bonded onto a SiO_2 coated host substrate. The I-MSM PD material was a 1 micron undoped GaAs layer grown on an AlAs sacrificial etch layer. Standard metal MSM fingers were defined, followed by etching of $300 \times 300 \mu\text{m}^2$ square mesas. The LED was a double-heterostructure PpN AlGaAs/GaAs/AlGaAs with an AlAs sacrificial etch layer. AuZn served as an ohmic p-contact, and $100 \times 100 \mu\text{m}^2$ mesas were defined. Both devices were then separated from their growth substrate using thin film integration and a transfer diaphragm, and were bonded to the host Si substrate, which had contact pads deposited onto it. The I-MSM was integrated onto the pads on the SiO_2 , first. After verifying that the device worked properly, the first benzocyclobutene (BCB) isolation layer was spun on and cured. After defining the LED bottom contact pad, the LED was integrated onto the pad that was centered in the middle of the I-MSM PD. A second BCB isolation layer was spun on and cured, and a contact window was opened, followed by top contact deposition and definition.