described in eqn. 6. It can be seen that the average sidelobe level and the beamwidth are approximately equal to \(-30\) dB and \(3.2^\circ\), respectively. In Fig. 3, the beampattern is obtained by the alternative approach described by eqn. 7. In this case, \(i\) is set to two and the regions of integration are

\[ \Phi_1, \Phi_2 = [6^\circ, 90^\circ] \]

and

\[ \Phi_1, \Phi_2 = [-90^\circ, -6^\circ] \]

It can be seen from the figure that the sidelobe level is improved approximately by \(25\) dB at the expense of widening the beamwidth to about \(4.6^\circ\).

Conclusion: It is shown that using the proposed computer-aided approach, an array beampattern, with an adjustable beamwidth corresponding to the minimum average sidelobe level for certain specified spatial regions, can be achieved. This simple approach may be extended to a more general situation where the signals involved are broadband signals incident with a certain elevation angle. This can be accomplished by an integration over the required regions of frequency and spatial angles. Note that this is applicable to both broadband and narrowband beamforming structures.

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NONLINEAR Y-JUNCTION COUPLER

We propose a new structure for a symmetric single-mode Y-junction coupler to achieve an insertion loss down to \(0.22\) dB by using the optical Kerr effect in a nonlinear medium. The power dependence of the coupling efficiency and a picture of wave propagation are presented and discussed.

The single-mode Y-junction coupler is one of the most important elements in optical-waveguide circuits. The performance of this coupler has been investigated extensively. For a symmetric single-mode Y-junction coupler, there is an inherent 3 dB insertion loss when the light comes from one arm of the branching fork. In this letter we propose a new structure for the symmetric single-mode Y-junction coupler using the nonlinear Kerr effect. With proper design and input power, the insertion loss can be greatly reduced to \(0.22\) dB.

The proposed Y-junction coupler is shown in Fig. 1. Two-dimensional structure is considered for simplicity. The structure can be divided into three sections, as shown in the figure.
output power $P_{in}$ and the input power $P_{in}$. In Fig. 3, we plot the coupling efficiency $E_{cou}/E_{in}$ as a function of normalised input power $P_{in}/P_{in}$, where $P_{in} = 0.214 W/mm^2$. When $P_{in} < P_{in}$, the coupling efficiency attains its maximum value, over 95%, i.e. the minimum insertion loss of the structure is less than 0.22 dB. When the normalised input power lies between 0.7 and 1.4, the insertion loss of the structure does not exceed 10% or 0.46 dB.

The nonlinear Y-junction coupler can be generalised to an $N$ to 1 coupler. If the branching angle between one of the branches and the straight waveguide increases, the coupling loss increases. Therefore, the waves incident from an outside branch suffer a higher loss. On the other hand, if we keep the angle small, we are forced to lengthen the nonlinear medium and the loss due to scattering and absorption in the nonlinear medium increases.

In conclusion, we have proposed a new structure for a symmetric single-mode Y-junction coupler, where a medium with Kerr nonlinearity is used. When the wave is incident from one of the branches, the insertion loss of the structure is very small compared to the 3 dB loss of the ordinary symmetric single-mode Y-junction coupler. The nonlinear coupler can be used in time division multiplexing (TDM) systems, and it is expected to have many other applications in all-optical signal processing.

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HIGH PERFORMANCE RESONANT TUNNELLING STRUCTURES ON GaAs SUBSTRATES

Indexing terms: Semiconductor devices and materials, Gallium arsenide, Tunnelling.

GaAs-based resonant tunnelling structures of high quality were grown by molecular beam epitaxy. Room temperature peak-to-valley ratios of 48 for GaAs/AlGaAs double barrier quantum well, 41 for GaAs/AlGaAs with InGaAs quantum well and 59 for GaAs/AlGaAs with adjacent InGaAs 'prewell' were obtained, in connection with reasonable peak current densities.

Key parameters in the performance of resonant tunnelling structures based on double barrier quantum wells (DBQW) are peak current density $j_p$ and peak-to-valley ratio (PVR) in the $I/V$ characteristics. The optimisation of a structure to obtain high $j_p$ is well understood, but the influence of structural and layer growth parameters on PVR has remained rather elusive. Theoretical investigations have pointed out the limitation of PVR by inelastic scattering (which crucially depends on material and interface quality). The practical limits for the obtainable PVR are unclear. Previously PVR in GaAs/AlGaAs structures at room temperature has been below 4.2.

The work presented in this letter was aimed at:
(i) trying to improve the performance, in particular PVR, of device-oriented DBQW structures in the GaAs/AlGaAs system and
(ii) the assessment of the advantages of inserting pseudomorphic InGaAs layers either as a central potential well or as a small-bandgap 'prewell' adjacent to a conventional DBQW.

Experimental data on such structures is scarce and seems to indicate that up to now their performance is clearly inferior to those with GaAs well (PVR $< 2$). It has recently been demonstrated that an InGaAs prewell can enhance both the PVR and $j_p$. This is attributed to a lowering of the space charge barrier for the injected electrons.

The design of our layer structures was guided by previous optimisations in DBQW's realised by metalorganic vapour phase epitaxy.

The essential parts of the structures are shown in the lower parts of Figs. 1-3. Our standard structure (A, Fig. 1) consists of 30 Å wide Al$_x$Ga$_{1-x}$As barriers with $x = 0.6$ and a 40 Å GaAs well. It is sandwiched between 150 Å thick undoped.

ELECTRONIC LETTERS 1st March 1990 Vol. 26 No. 5