LOW POWER ALL-FIBRE INTENSITY MODULATOR AT 2.7MHZ

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Abstract

A monolithic single-mode fibre acouso-optic amplitude modulator is reported. Nearly 100% modulation is achieved at a modulation frequency of 2.7MHz for an electrical drive power of 2mW.

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Many previously described intensity modulators [1,2,3] suffer from large insertion losses. Here we report a device with improved specifications (0.5dB total loss and 2mW drive power) that is based on a fused tapered coupler.

The coupler was constructed with two identical fibres, so when light is launched into either input port, the fundamental and second order modes of the coupler waist are equally excited [4]. If a flexural acoustic wave is applied to the waist in the plane of the fibres, such that the acoustic wavelength is equal to the beat length between the two modes of the coupler waist, there is resonant coupling between them [5]. Simultaneously, the light that is coupled between the modes is frequency shifted due to the travelling acoustic wave, figure 1.

Light initially in one mode will be upshifted in angular frequency by Ω, while light initially in the other mode will be downshifted by Ω.

In a coupler the phase difference between the two waist modes determines the power splitting between the output ports. With the device passive, this phase difference is a function of the length of the waist, its width, the refractive index of the fibres, and the wavelength of the input light. When active this phase difference is also a function of time since the two modes now possess different frequencies. The angular beat frequency is 2Ω and thus the intensity in either output port will vary as $\cos 2\Omega t$.

Our device was made using 125μm fibres for single mode operation at 633nm. The coupler had a uniform waist 25mm long and 6μm in diameter. The excess loss was 0.2dB. The acousto-optic resonance was at an acoustic frequency of 1.36MHz; an intensity modulation of more than 93% at 2.72MHz could be obtained in both output ports, as shown in figure 2. This was achieved with less than 0.3dB induced loss and required only 2mW RF drive power.

Low loss intensity modulators have uses for Q-switching [6], or mode-locking lasers, or even cavity dumping. Initial results are promising for the manufacture of a similar device at 1.55μm and drive frequencies up to 500MHz. Such a device would be useful as an intensity modulator in a soliton laser system. A high power pulsed source at 1.55μm could be used in many applications including nonlinear optics, laser ranging and remote sensing, eyesafe free-space communication and long-distance optical time domain reflectometry.

References

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Figure Caption

1. Resonant coupling between the fundamental and second modes of a coupler waist, caused by a flexural acoustic wave of angular frequency Ω.

Figure Caption

2(a) Optical power emerging from one port of the coupler.

2(b) Optical power emerging from the other port of the coupler.

2(c) RF signal applied to the acoustic transducer at 1.36MHz.

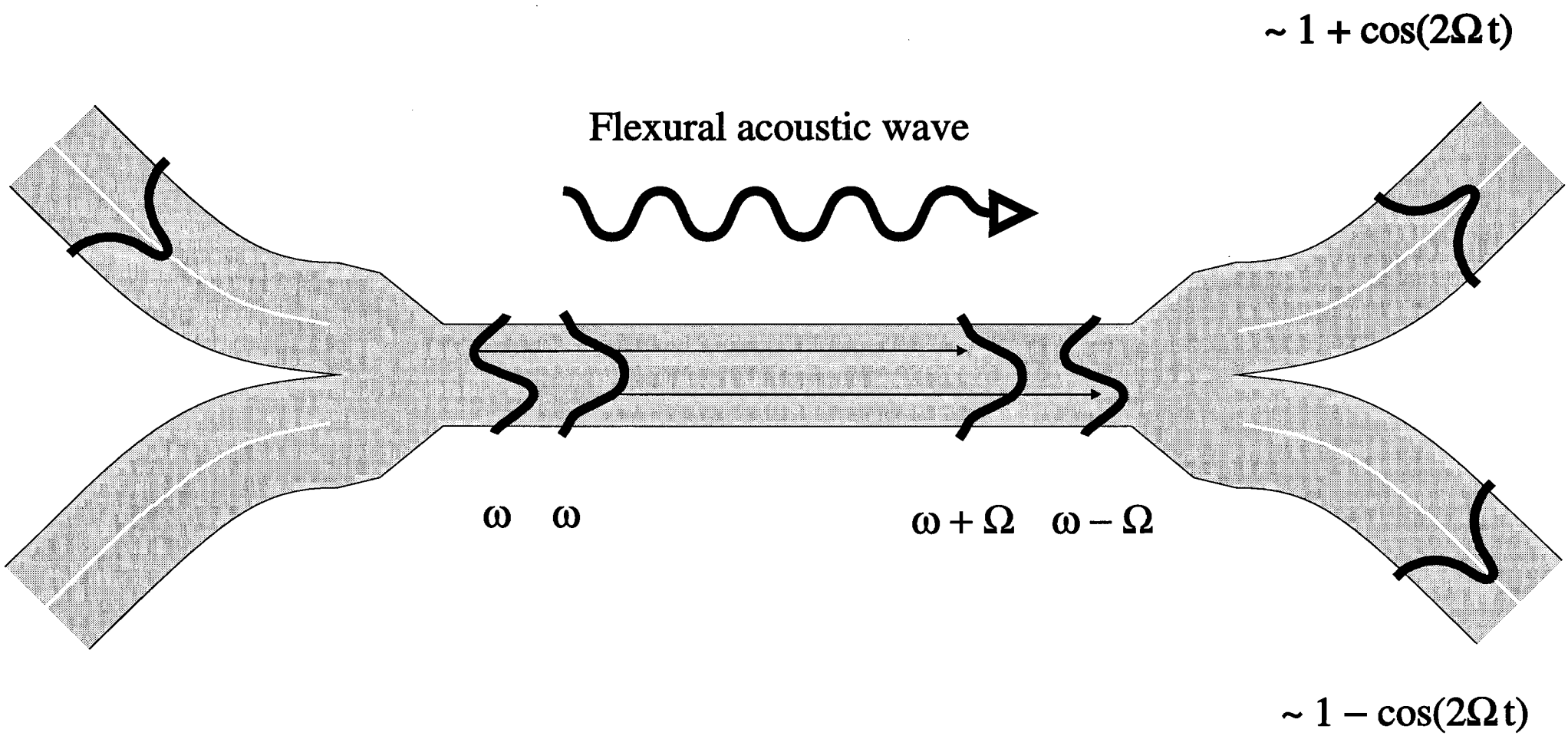

Figure 1

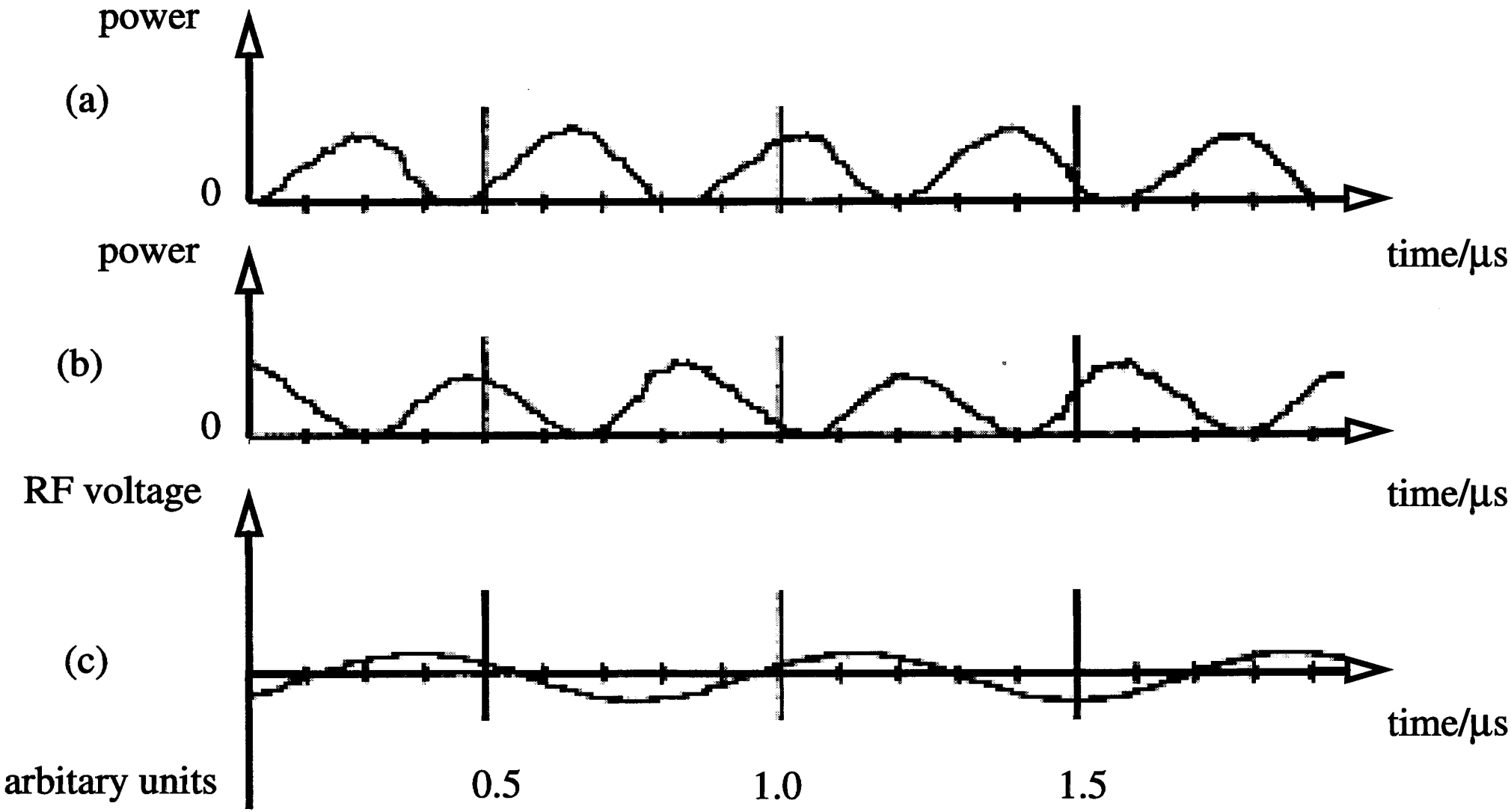
power
(a)
0
time/μs
power
(b)
0
time/μs
RF voltage
(c)
time/μs
arbitary units
0.5
1.0
1.5

Figure 2