

Monolithically Integrated InP Photonic Micro Systems on a chip for O-CDMA and OAWG applications

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Abstract: A monolithically integrated InP chip for optical arbitrary waveform generation (OAWG) and/or pulse-coding/decoding is demonstrated using a 20-GHz AWG pair and 10 high-speed phase modulators. The fabrication and performance of the InP chip will be presented.

Keywords: Optical Arbitrary Waveform Generation, Optical Code-Division Multiple Access, Integrated Optoelectronics.

1. Introduction

Pulse shaping using phase- and amplitude manipulation of optical spectral components allows user-specified optical waveform generation. This leads to diverse applications in optical communications, RF photonics, electronic testing, THz radiation, and radar [1,2,3,4]. In many applications, monolithic integrated and miniaturized systems are essential for reliable operation, low-cost manufacturing, and functional scalability. In this paper, we present a monolithically integrated InP chip for ultra-short pulse shaping using a AWG pair and amplitude/phase modulators. Section 2 describes the design and fabrication of an OAWG InP chip. Measurement setup and results are given in section 3.

2. Design and Fabrication

Figure 1a shows the design of a monolithic integrated InP chip for OAWG (or O-CDMA, which is a particular case of OAWG). The wavelengths of an input short pulse are de-multiplexed onto ten different waveguides by a de-mux AWG. The design of this 20-GHz channel-spacing AWG has been elaborately described in [5]. And then, each wavelength passes through an electro-absorption-based amplitude modulator and an electro-optic-based phase modulator, with which we can control electronically the amplitude and phase of each wavelength. Afterwards, the ten wavelengths are multiplexed onto a single waveguide and coupled out of the chip using a mux AWG. User-specification of OAWG is done by amplitude- and phase modulation of ten different waveguides between two AWGs.

Figure 1b shows the fabricated OAWG InP chip. The OAWG chip was fabricated in InP technology, which has the advantage that we can realize compact AWGs together with high-speed electro-optic switches. On top of a semi-insulating InP substrate, we have epitaxially grown the

following structure in a metal-organic vapour-phase-epitaxy (MOVPE) reactor: a 0.5- μm i-InP buffer layer, a 0.05- μm Q(1.25) Etch stop layer, a 0.6- μm n-InP spacer layer, a 0.1- μm n-doped InGaAs contact layer, a 2- μm n-doped InP lower-cladding layer, a 0.5- μm Q(1.15) waveguide core layer, a 2- μm p-doped InP top cladding layer layer, and a 0.1- μm p-doped InGaAs layer. Afterwards, the 4- μm waveguides were etched in a Br_2/N_2 reactive beam etcher using a 550-nm SiO_2 layer as mask. Then, Fe-doped semi-insulating InP was regrown by low pressure hydride vapour phase epitaxy (HVPE). Afterwards, we etched the Fe-doped InP (next to the modulators) down to the bottom InGaAs layers to access the n-contacts. Finally, we isolated the structure with Benzocyclobutene (BCB) and patterned TlPt/Au (30-nm/30-nm/1- μm) of coplanar-waveguide metal lines.

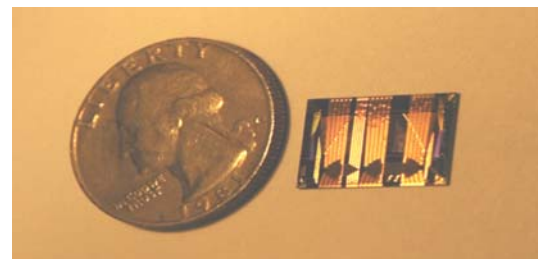
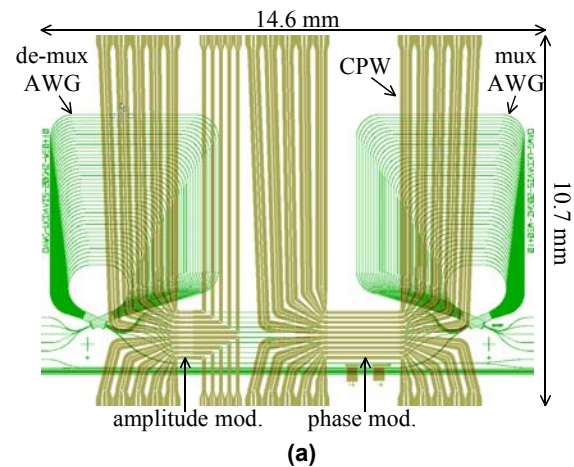
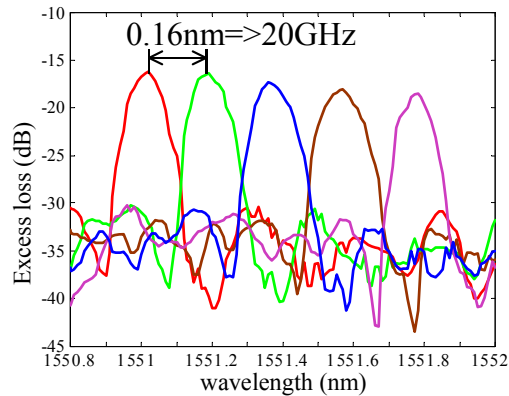


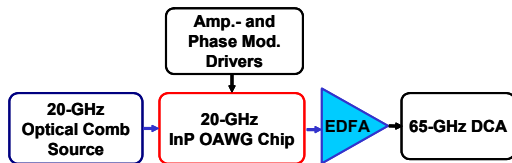
Figure 1 : Design of the InP OAWG chip (a), and picture of the fabricated device (b) (CPW=coplanar high-frequency waveguide).

3. InP-OAWG-Chip Measurement and results

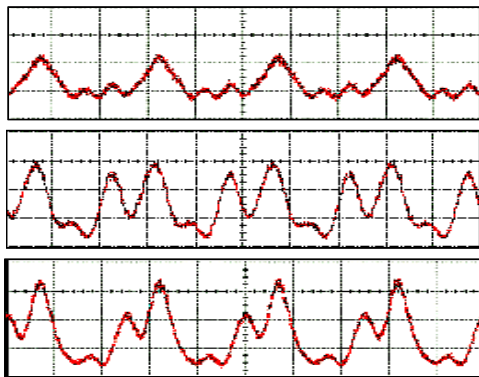
Figure 2a shows the transmission characteristics of the individual AWGs. The measured channel crosstalk is around 15 dB. We have conducted waveform generation experiments using the set-up shown in figure 2b. Our light source consists of an optical comb source with which we can generate an arbitrary number of coherent wavelengths that are spaced 20GHz (= 0.16 nm) apart [6]. For this particular case, we have configured the comb source to generate ten wavelengths centered around 1550nm. These ten wavelengths are then coupled into the InP OAWG chip with a lensed fiber. The de-muxed signals are modulated with modulators and combined with the other AWG into the output waveguide. After the chip, the optical signal is amplified with an EDFA and the arbitrary waveform is visualized with a 65-GHz digital communications analyzer (DCA).



(a)



(b)



(c)

Figure 2 : Measured AWG transmission (a), measurement setup (b), and generated waveforms by applying different bias voltages to different phase modulators (c).

Figure 2c shows the generated waveforms when applying different voltages to the different phase modulators. These plots clearly demonstrate the waveform change for different applied voltages.

4. Conclusion

We have successfully demonstrated optical arbitrary waveform generation with a compact monolithically-integrated InP-based chip (14.6x10.7 mm²). The 20-GHz AWGs show a channel crosstalk of around 15 dB.

5. References

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