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FAST LIGHT GENERATION USING GaAlAs/GaAs WAVEGUIDE

A. AFROOZEH[1,2*], M. BAHADORAN[3], I. S. AMIRI[4], A. R. SAMAVATI[5], J. ALI[6] & P. P. YUPAPIN[7]

Abstract. Generation of fast light pulses through a nonlinear microring system is an attractive research challenge for high speed optical and quantum computer, optical communication networks and secured communication. In this paper generation of fast light through GaAlAs/GaAs waveguides with fabricated Micro Ring Resonator is reported. Using multistage system, the attosecond pulse can be generated. Simulation results obtained have shown that the generation of a very narrow full-width at half maximum (FWHM) line width and sharp tip is achieved. We propose a new system of multistage micro ring resonators consist of four rings for optical communication system. Here, pulse width of 15 attosecond can be obtained, using proper parameters of the proposed system.

Keywords: Microring resonator; optical communication; attosecond pulse

1.0 INTRODUCTION

Recently, microring resonators have been of interest in many applications of secured communication, mobile and networks. The most important applications consist of store of light in optical buffers [1], electro-optical modulators [2], and polarization of signals [3, 4]. Conversion of frequency is applicable by varying the resonant frequency of a microring while a signal can be narrow inside [5, 6]. Several methods have been reported for using in the generation of attosecond pulses. Biegert and Keller showed that generation of sub femtosecond pulse can be done

[1,3,4&6] Institute of Advanced Photonics Science, Nanotechnology Research Alliance Universiti Teknologi Malaysia (UTM), 81300 Johor Bahru, Malaysia
[2] Education Organization of Fars, Iran
[5] Ibn Sina Institute for Fundamental Science Studies, Universiti Teknologi Malaysia
[7] Nanoscale Science and Research Alliance (N'SERA), Faculty of Science King Mongkut's Institute of Technology Ladkrabang, Bangkok 10520, Thailand
* Corresponding author: afroozeh155@yahoo.com

[7, 8]. Yiping Hou *et al.* showed generation of optical pulse which has width of 40as in multicycle driver regim [9]. Recently Yupapin *et al.* have generated attosecond pulse of 50 as in micro ring resonator which is made of InGaAsP/InP [10]. In this work, we use multi ring resonators consisting of four rings, shown in Figure (1). These rings have been made form GaAlAs/GaAs [11].

Attosecond pulse from the output of microring resonators can be achieved by fabrication using GaAlAs/GaAs material. Various authors have also reported external electro-optic modulators based on GaA1As/GaAs [12]. Most of the research on GaAlAs/GaAs waveguide modulators has been at 1.33 µm. Significant successes using the former approach have been reported. The LiNbO3 devices are not chip level integrable with semiconductor lasers using current technology. Numerous authors have also described high speed GaAs-based optical detectors, including a Schottky hotodiode that is useful to 100 GHz, and GaAlAs/GaAs-based detectors have been reported [13, 14]. The demonstration of picosecond response times in the case of InGaAs-matrix material in this work opens up new vistas for implementing receiver and terahertz technology with the help of 1.55 µm optical components such as compact user-friendly femtosecond pulsed fiber sources. Signal attosecond pulses are recognized as the important tool for improvement in different optical research areas. Areas of applications are lithography, compact disk writing and reading, surface roughness, high-speed switching and communication, high-speed optical and quantum computer [15]. In this paper we discuss the results obtained to date on the performance of an attosecond pulse generation using two martial in form of microring resonators. Figure (1) shows the proposed system which is consisting of multistage microring resonators with same radii.

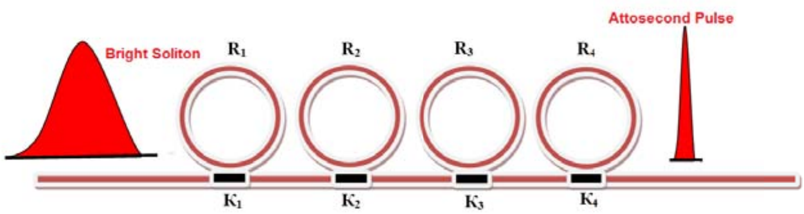


Figure 1 Schematic of multistage micro ring resonators

2.0 FUNCTION OF SYSTEM

In order to generate attosecond light pulse, the optical bright soliton is fed into the series of micro ring resonators. The input optical field in the form of bright soliton pulse can be expressed by Equation (2.1) [14].

$$E_{in} = A\operatorname{sech}(\frac{T}{T_0})\exp[\frac{z}{2L_d} - i\omega_0 t] \tag{2.1}$$

where T is propagation time of soliton pulse, A and z are amplitude of the optical field and distance of propagation respectively. T is a soliton pulse propagation time, L_d is the length of dispersion for soliton pulse. Initial time of input soliton pulse during propagation is shown by T_0 and t is the time for phase shift where the frequency shift of the soliton is ω_0. When the optical field input in the MRR's, the relationship between the output and input optical field expressed by Equations (2.3) and (2.4).

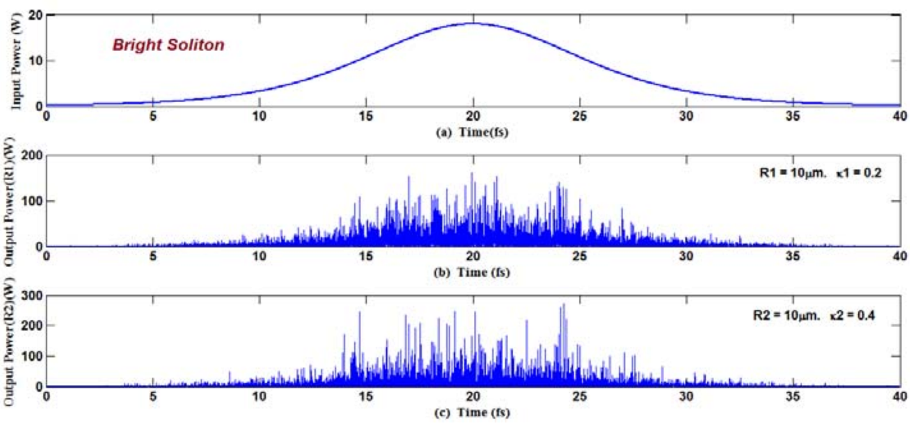
$$E_{out1} = E_{in}(\frac{\sqrt{(1-\kappa_1)(1-\gamma_1)} - (1-\gamma_1)\exp((-\alpha L_1/2) - jK_n L_1)}{1 - \sqrt{(1-\kappa_1)(1-\gamma_1)}\exp((-\alpha L_1/2) - jK_n L_1)}). \tag{2.3}$$

$$P_{out} = (E_{out}).(E_{out})^* = |E_{out}|^2 \tag{2.4}$$

Here κ is the coupling coefficient, and K_n shows the wave number in a vacuum. γ is the fractional coupler intensity loss. L is circumference of ring, α and γ are the absorption coefficient and intensity loss respectively. Exp (αL/2) is a roundtrip loss coefficient.

3.0 RESULTS AND DISCUSSION

The GaAlAs/GaAs can be used to make the micro ring resonators where, soliton pulse with centre wavelength of 1.33 μm, pulse width of 10 fs and power of 18 W is input into the proposed system as shown in Figure 2(a). The radii of the microrings have been chosen as, R_1=7 μm, R_2=7, R_3 =7 μm, and R_4=7 μm. Selected parameters of the system are fixed with n_0 = 3.3, and the waveguide loss of 0.2 dB/mm is noted. The coupler intensity loss is 0.1 and the nonlinear refractive index is $n_2 = 1.4 \times 10^{-12} \frac{m^2}{W}$. The soliton pulse is coupled into the system where the coupling coefficient varies from 0.2 to 0.6. When a soliton pulse is input into the system, the chaotic and amplified signals can be generated. The roundtrip of 20,000 times inside the system can be simulated. The input bright soliton pulse is sliced and amplified into the smaller signals over the spectrum shown in Fig. 2(b), 2(c), 2(d). Filtering of the chaotic signals is shown in Figure 2(e). Output signals from the system are simulated using MATLAB programming. Figure (3) shows the expansion of Fig 2(e) for attosecond pulse generation which has pulse width of 15as and output power is 1400 W.



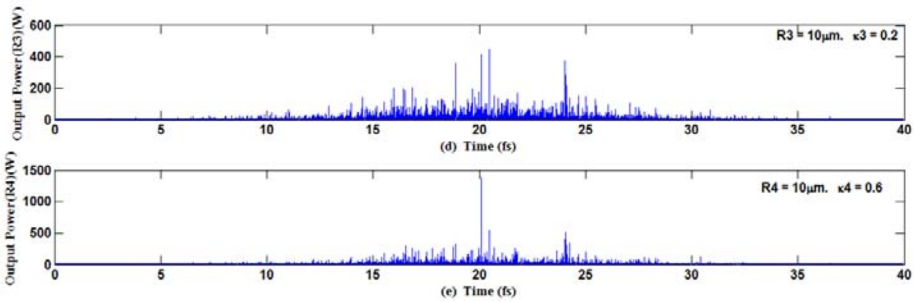


Figure 2 Result of the output signals from proposed system where (a) shows the input bright soliton pulse, (b) and (c) the chaotic signals generation, (d) the amplifying and filtering signals, (e) the attosecond pulse generation

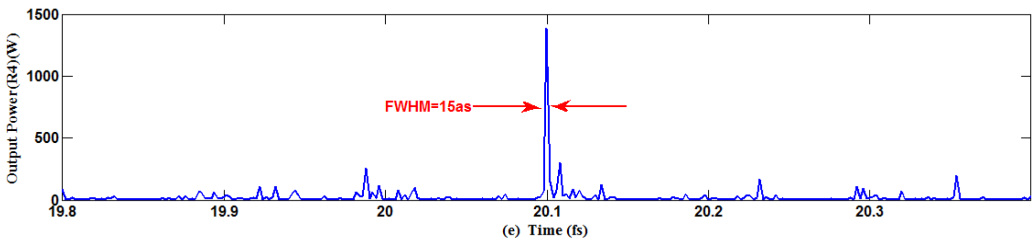


Figure 3 Expansion of Fig 2(f) for attosecond pulse generation

4.0 APPLICATIONS OF ATTOSECOND PULSE

Attosecond pulses have been the broad areas of investigation in many subjects, which is recognized as the important tool for fast improvement of frontier research in the areas. For example, areas of applications such as high small-scale lithography, high-density compact disk writing and reading, high-resolution interferometer and surface roughness, high-speed switching and communication, high-speed optical and quantum computer are included. In applications, the roundtrips time at the resonant peak power can be adjusted, where the required signal width can be selected and used. Further, the pulse width beyond the attosecond can be generated when the same principle is performing. Signal attosecond is available for the applications such as the new generation of ultrafast switching and lithography, high resolution image construction [16, 17]. One of the most interesting properties of attosecond pulses is that their short pulse duration allows us to measure both phase and amplitude of an unknown wave function or wave packet by pump-probe interferometric methods [18, 19], giving us access to the temporal dynamics of the process that led to this wave-packet. In this study, we described some of these applications, and in particular recent results concerning measurement of single photo ionization dynamics using an attosecond pulse train [20].

5.0 CONCLUSION

We have proposed the novel system to generate interesting results of attosecond soliton pulse using multi-stage MRR's. We have shown the results of attosecond generation from semiconductor materials which have been used to make MRR's. Here extremely narrow soliton pulse in the range of 15 as could be generated using GaAlAs/GaAs material. Detection of narrow pulse is the problem in the realistic application due to the optical material bandwidth limitation. Therefore, the detection technique has become interesting subject of investigation. However, the attosecond pulse is useful for optical lithography, high-speed optical switching and communication.

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