Terahertz fiber laser based on a novel crystal fiber converter

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***Abstract*—We proposed a novel GaAs-based crystal fiber converter for efficient THz difference frequency generation, which combines the single-mode THz fiber and the quasi-phase-matching configuration. Calculations were performed on the characteristics of energy conversion and output beam focusing. Theoretical results indicated that the proposed THz fiber laser can provide high power and high brightness THz source.**

I. INTRODUCTION

Difference frequency generation (DFG) from laser pulses with two close wavelengths is an established technique way for monochromatic THz generation [1], which possesses several advantages. Considerable work has been done to improve the conversion efficiency and output power from different aspects [2,3]. Pump beam focusing is usually necessary, especially for THz-DFGs in the high repetition rate and continuous-wave regimes. However, the diffraction of generated THz waves is unavoidable when the pump laser beam is focused to a size comparable to THz wavelength. This effect not only influences the overlap between the THz radiation and the pump laser during the course of propagation, decreasing the conversion efficiency, but also deteriorates the THz beam quality. One approach to solving this problem is to utilize a waveguide structure. On the other hand, in a waveguide structure the pump intensity is limited by the damage threshold of the nonlinear material; picosecond laser pulses generally correspond to higher peak power, modest average power and high damage threshold. Thus, THz-DFG with a waveguide structure pumped by ps-pulses is clearly worth investigating.

In this paper, we propose a GaAs-based THz crystal fiber converter for efficient THz-DFG with high brightness.

II. RESULTS

Schematic of the THz crystal fiber converter is illustrated in Fig. 1. This axisymmetric structure consists of a periodically inverted GaAs core clad with index-matched chalcogenide glass [4], which functions as a single-mode fiber for THz radiation. This scheme offers two advantages: (i) THz radiation is confined inside the core and well overlapped with the pump laser over the entire interaction length, to increase the conversion efficiency; (ii) only one intrinsic THz mode (LP_{01}) can be generated with high gain in this structure, which contributes to the high THz beam quality. We consider an experimental situation where the crystal fiber is pumped by ~2 μm ps-pulse fiber laser and develop the guided-wave coupled-mode equations for quasi- monochromatic pulses. The output power, spectral power density and brightness are analyzed, based on the calculation of the dynamic of energy conversion and the characteristics of the THz beam focusing (Fig. 2). High output power (average ~1 W) and excellent focusing characteristic allow us to achieve THz generation with high brightness (100 MW/(sr·cm^2)), a promising value for many applications.

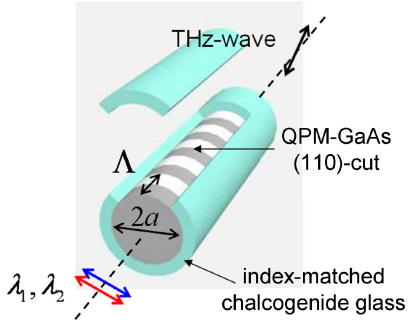

Fig. 1. Schematic diagram of the THz crystal fiber converter.

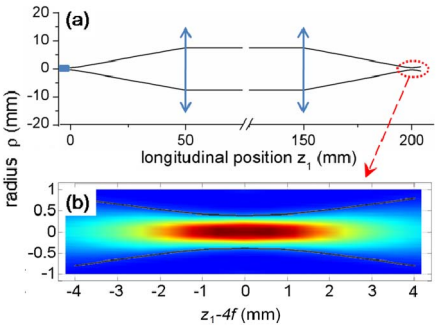

Fig. 2. Evolution of THz beam through a 4*f*-system (a) and microscope of the focal region (b).

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