GPU accelerated Examination on Transmission Properties of FBG

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1. Introduction

Fiber Bragg grating (FBG) has an important role for the optical amplifier and filter of the optical system. An optical amplifier would not work well without the existence of FBG [1]. FBG can reflect, transmit or filter a certain wavelength based on the design [2]. In this research, FBG is assumed to be modelled by the three-dimensional periodic structures where a single mode can propagate. Finite difference time domain (FDTD) method is used to simulate and analyze FBG structure [3]. Graphics processing units (GPU) computing is used to get faster simulation time [4].

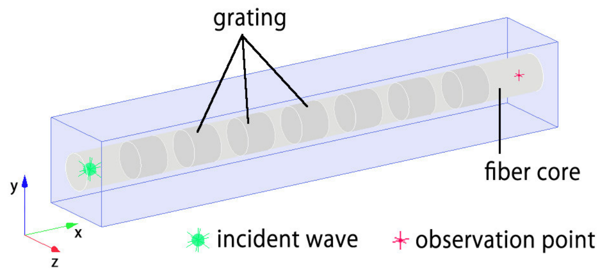

Fig. 1 Illustration of FBG structure simulation area.

2. Numerical Simulation and Results

FBG structure simulated in this paper is illustrated in Fig. 1. For simulation parameter, the analytical region is x=210μm y=z=7μm, the length of grating structure is up to 200μm, the core width is 3μm. Refractive index of the cladding is n_3=1.44, while core refractive index is n_2=1.46, and grating refractive index n_1=1.47. Cell sizes are set to be $\Delta x=\Delta y=\Delta z=0.1\mu m$, and the time step size $\Delta t=1.92583\times10^{-16}$s is used. The grating period is set as Λ=529nm. Corresponding frequency center $f_0=1.93\times10^{14}$Hz. Data collected in time domain will be further processed by using fast Fourier transform (FFT) technique to get output characteristic in frequency domain.

Specification of the computer system that used for this simulation are:

- Intel® Xeon® E5520 @2,27Ghz, 4 core 8 threads
- 8GB DDR3-8500 triple channel
- Windows 10 64 bit
- GTX Titan X, 3072 CUDA cores 12GB GDDR5 384-bit

Fig. 2 and Fig. 3 show that results from Central Processing Unit (CPU) and graphics processing units (GPU) computing are indistinguishable. Table 1 show that the GPU computation speed could reach 100 times faster than single thread CPU computing and around 33.3 times faster than by using all 8 CPU threads.

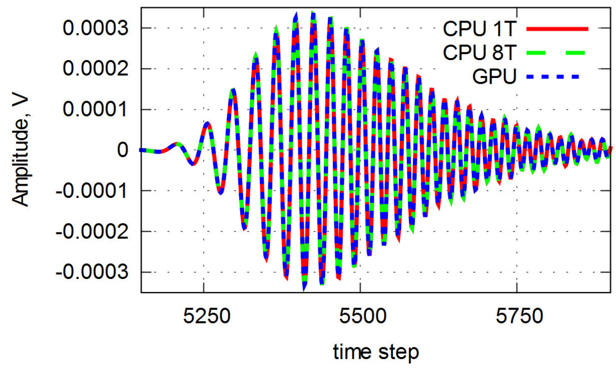

Fig. 2 Transmission properties in time domain.

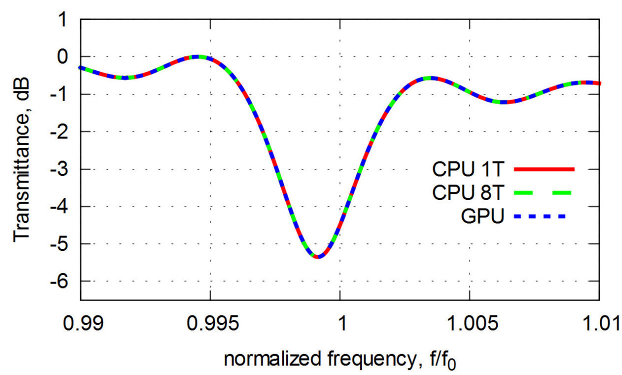

Fig. 3 Transmission properties in frequency domain.

Table I

Time Performance Comparison for CPU and GPU

Simulation scheme	Simulation times		Faster time Multiplication
	hh:mm:ss	second	
CPU (1 thread)	10:55:15	39,315	1 x
CPU (8 threads)	03:35:42	12,942	3.038 x
GPU computing	00:06:28	388	101.327x

3. Conclusion

FBG structure was simulated successfully by using FDTD methods utilizing CPU and GPU computing. Up to 100x faster simulation time was obtained by using GPU computation, with indistinguishable result in transmission properties compared to CPU calculations.

4. References

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[3] Miyamoto T., Momoda M., and Yasumoto K., "Numerical analysis for 3-dimentional optical waveguide with periodic structure using Fourier series expansion method," *IEICE Trans. Japan* (section J), J86-C, no. 6, pp.591-600, 2003.

[4] P. Klapetek et al., "Rough surface scattering simulations using graphics cards," *Applied Surface Science*, 256, pp 5640-5643, 2010.