行政院國家科學委員會補助專題研究計畫成果報告

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計畫類別：■個別型計畫　　□整合型計畫
計畫編號：　NSC　89－2112－M－009－070
執行期間：　　89 年　8 月　1 日至　90 年　7 月　31 日

計畫主持人：潘犀靈 教授
共同主持人：黃中垚 教授

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執行單位：國立交通大學光電工程研究所

中　華　民　國　　90 年　　7 月　　31 日

用時間閘 FROG 法研究鎖模雷射脈衝形成動力學

Investigation of Pulse Buildup Dynamics of Mode-locked Lasers by Time-Gated FROG Method

計畫編號：NSC 89－2112－M－009－070

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一、中文摘要

我們發展了一種新型的超快脈衝量測技術：時間閘 FROG**。利用此方法，我們將得以探討鎖模雷射在脈衝形成過程中的演變情形。以一具利用飽和式** Bragg **反射鏡的被動鎖模鈦寶石雷射為例，我們初步證實了此一方法之可行性。**

關鍵詞： **鎖模雷射、脈衝形成動力學、脈衝量測技術、時間閘、**FROG

Abstract

We propose and demonstrate a new type of ultrafast pulse diagnostic technique – time-gated frequency resolved optical gating or TG-FROG. Using TG-FROG, it is possible to determine the evolution of both the amplitude and phase of the optical field as the laser evolves from the laser onset to steady state pulse train. To demonstrate, we investigate the pulse buildup dynamics of a self-starting passively mode-locked Ti:sapphire laser with a saturable Bragg Reflector (SBR). Valuable insight about the laser was obtained using this method.

Keywords: mode-locked laser, pulse buildup dynamics, pulse characterization, frequency-resolved optical gating, time-gating

二、Introduction

The ability to characterize ultrashort pulses is vital to the advance of ultrafast lasers. Pulses as short as a few cycles have been successfully characterized by either Frequency Resolved Optical Gating (FROG) or Self-referencing spectral interferometry (SPIDER). [1,2] To the best of our knowledge, the transient state of optical pulse field (i.e., amplitude and phase) as the laser evolves from noise to steady state mode-locked pulses have not been reported. Previous studies on the buildup dynamics in ultrafast lasers mostly rely on the buildup time as determined by the buildup of the second harmonic signal of the pulse train. Further insight can be obtained by analysis of the transient autocorrelation traces. [3] Neither technique provides phase information on the optical pulse field, which should also play an important role in the buildup process. In this work, we report for the first time a new technique that allows dynamic optical pulse field (both amplitude and phase) measurement.

三、Experimental Methods

There are two main part of the experiment, one is FROG and the other is time gating system. A schematic of the experimental setup is shown in Fig. 1. We use two phase-locked optical choppers to gate the laser output that was fed to a standard FROG apparatus. The timing diagrams of the choppers are shown in Fig. 2. The intra-cavity chopper (chopper 1) periodically blocks the laser at 500 Hz. The extra-cavity chopper (chopper 2) opens a time window of about 20 μs for the chopped beam. The relative jitter of the opening times of the two time-windows is about 1 μs. By adjusting the phase difference between the choppers, we obtain the FROG trace of the transient laser output at a certain delay time relative to the laser onset. The buildup dynamics of a self-starting passively mode-locked Ti: sapphire laser with a saturable Bragg Reflector (SBR) [4] was investigated. The average output power of the laser is 300mW. It generates ≈150 fs pulses at 82 MHz.

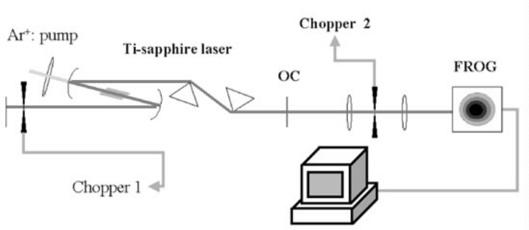

Fig.1 The experimental setup of buildup dynamics.

Fig. 2 Timing Diagram of the two choppers

三、Results and Discussions

In figures 3 to 5, we show the typical FROG trace and retrieved intensity and phase of the laser output at the delay time 126, 187, and 841 μs with respect to the laser onset. These correspond to the initial, mid-point, and final stages of the buildup process respectively. The FWHM durations of the steady pulses (Fig. 5) are 150 fs, in agreement with direct intensity autocorrelation results. We observed highly asymmetric pulse field during the early stage of buildup (with high-order chirp). In the steady state, the pulse is almost symmetric. This is attributed to the use of the SBR, which initiates saturable absorber action.

Fig. 3(a) FROG trace obtained during the initial stage of the build up (delay time = 14 μs)

Fig. 3(b) Retrieved Pulse field during the initial stage of the build up (delay time = 14 μs)

Fig. 4(a) FROG trace obtained at the midpoint of the buildup process (delay time = 157 μs)

Fig. 4(b) Retrieved pulse field obtained at the midpoint of the buildup process (delay time = 157 μs)

Fig. 5(a) Steady-state FROG trace of the femtosecond Ti: Sapphire/SBR laser

Fig. 5(b) Retrieved pulse field of the steady state

Note that the cubic chirp term increases initially and then decreases to a state state value.

四、Conclusions

In summary, time-gated FROG is proposed and demonstrated for the first time. Initially results on the transit temporal phase evolution during the buildup of a passively mode-locked Ti: sapphire/SBR laser are obtained.

五、參考文獻

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