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Burning damage threshold and combustion wave spread velocity of fused silica induced by long pulsed laser

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ABSTRACT

In order to study the fused silica's damage process under the action of long pulsed laser, this paper established automated diagnostic system,which according to the characteristics of combustion wave which generated in the process of laser induced damage that it has obvious radiation in visible light band, and calculated the damage threshold of fused silica according to the system. Shadow method is used to establish the measurement experiment of spread velocity of combustion wave caused by long pulsed laser.

1. Introduction

Laser induced burning damage is one of the special phenomena in the process of interaction between laser and materials. When laser interacts with materials, the materials absorbs laser energy lead to the rising of its temperature, and then occur melting and vaporization. Vapor formed by the vaporization further absorbs the laser energy and produces low density ionization reaction, therefore appears a phenomenon which is called Laser Supported Combustion wave (hereinafter abbreviated as LSC wave) [1,2].

Fused silica is the preferred optical window material. It is widely used in the production of life, so it is very important to study the damage mechanism of laser interaction with fused silica. Many experiments have been done on the laser interaction with fused silica at home and abroad [3–8], but there are no reports about the burning damage and its damage threshold. LSC wave has strong characteristics of radiation in the visible light wave band. It is obviously different from laser induced target melting and vaporization [9,10] and can be received and displayed by high speed camera. In this article, we studied the laser induced damage threshold of fused silica and the propagation velocity of laser supported combustion wave.

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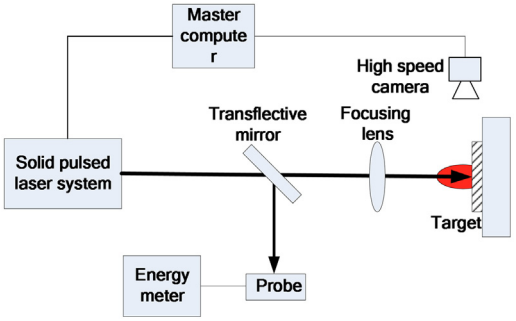

Fig. 1. Test system of laser induced burning damage threshold.

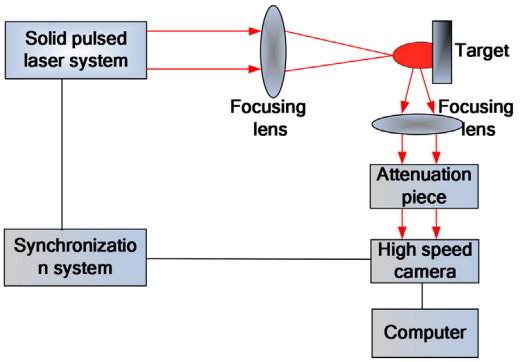

Fig. 2. Injection speed test schematic.

2. Experimental principle of laser induced burning damage threshold

Combustion wave which generated in the process of laser induced damage has obvious characteristics of radiation in the visible light band. According to that feature, an automated laser induced damage threshold of combustion diagnostic system is established. The system is based on whether it can be detected for a flash in a certain area within the time of laser input from beginning to the end. By using high speed camera, we can determine whether it generated the laser supported combustion wave.

When testing the damage threshold, each test point is irradiated by one pulsed laser on the target, but it must be irradiated at least 10 test points at the same energy density. Changing the laser energy and continue to test until the maximum energy density of laser who didn't induced the burning damage and the minimum energy density of the laser who induced the burning damage can be obtained. Then calculating the average value, the laser induced damage threshold of the target can be obtained. As shown in Fig. 1, the test system is as follows:

3. Experimental principle of combustion wave spread velocity

Fig. 2 shows the schematic diagram of the test system. It shows that long pulsed laser systems interact with materials to produce splashing. Synchronization system will give a synchronization signal to high speed camera before outputting laser,. The high speed camera shutter can be set by software. The shortest exposure time of the camera is 1 μs, exposure time can be adjusted from 1 μs to 60 s. High speed camera can shoot the target splash, and put it into a computer.

Use independent research and development of software to process the obtained interference sequence diagram, and get the velocity and distribution of splashing**.** In the time of high speed camera shutter was opened, taking into account the characteristics of sputtering substance shine, high speed camera will capture some linear trajectory. We use the length of the trajectory divided by the exposure time of the high speed camera equals the ejection velocity of sputtering materials.

4. Experimental results

Using high speed camera, the evolution of the damage process of fused silica under the effect of single pulse laser was divided into four cases by the method of plasma shadow.