Time-resolved measurement of stress field formed by femtosecond laser-induced stress waves in vitreous silica

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When a femtosecond laser pulse is focused on a solid surface, the solid is rapidly heated and removed. During this removal process, an intense recoil force is applied to the solid surface, generating stress waves that propagate inside the material. These stress waves are called femtosecond laser-induced stress waves and have many applications in various fields such as life sciences, medicine, solid state physics, and industry.

In some of these applications, especially in the field of laser processing, the complex stress distribution of the stress waves is important. Although there have been many simulation studies of femtosecond laser-induced stress waves, few studies have experimentally measured the three-dimensional profiles [1-2].

In this study, we measured the three-dimensional stress field of femtosecond laser-induced stress waves using a method that combines time-resolved Mach–Zehnder interferometry and time-resolved photoelasticity. Our newly proposed method allows the reconstruction of the three-dimensional axisymmetric dynamic stress field of the stress waves.

The stress waves are induced by the pump pulse with a wavelength of 1030 nm, pulse width of 180 fs and pulse energy of 200 μJ in a thin substrate of vitreous silica as shown in Fig. 1. The probe pulse passed through the glass from a direction perpendicular to the pump pulse. The stress waves were captured by both the Mach–Zehnder interferometer and the polariscope. After reconstructing the stress field using our proposed method, we obtained the stress distribution of the femtosecond laser-induced stress wave as shown in Fig. 2.

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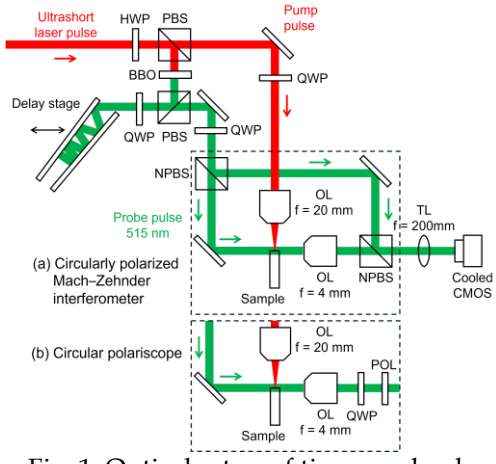

Fig. 1. Optical setup of time-resolved (a) Mach–Zehnder interferometer and (b) circular polariscope

References: [1] V.V. Shepelev, Yu.V. Petrov, N.A. Inogamov, V.V. Zhakhovsky, E.A. Petrov, et al.; [2] R. Ecault, L. Berthe, F. Touchard, M. Boustie, E. Lescoute, et al.

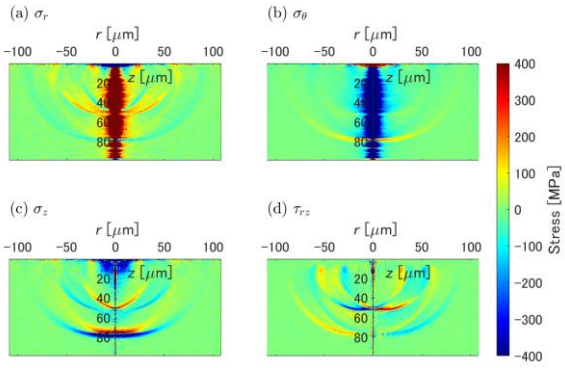

Fig. 2. Stress field measurement results of femtosecond laser-induced stress wave