Precision microprocessing of silica glass using a temporally shaped ultrafast laser

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Owing to the extremely high intensity and the small heat-affected zone, ultrafast lasers have been widely used for the microprocessing of transparent hard and brittle materials [1]. However, the great pressure applied on the base materials during the fast expansion of plasma results in severe cracks in the processing regions [2], which degrades the precision and makes the application limited. In recent years, several methos have been demonstrated to improve processing precision, including the GHz burst mode [3], transient and selective laser processing method [4], and liquid-assisted processing [5]. Nevertheless, these methods have either expensive equipment or complicated setups.

In this work, we achieve crackless precision processing through temporally shaping an ultrafast laser [6]. The experimental setup is shown in Fig.1(a). An ultrafast laser having a pulse duration of 5 ps is split into two sub pulses (P1 and P2). P1 is directly delivered into the silica glass sample for electron excitation. P2 is temporally stretched to ~300 ps using a CVBG, and then used to heat the electrons and achieve the material removal. Many cracks are generated at the inner side walls in the conventional single-pulse processing, as shown in Fig. 1(b), where the pulse numbers are 3000. By using the proposed method, the cracks are almost inhibited, as shown in Fig. 1(c). Moreover, the hole depth increases more than 3.3 times, and the aspect-ratio is improved at least 2.2 times. This method provides a new route for the precise processing.

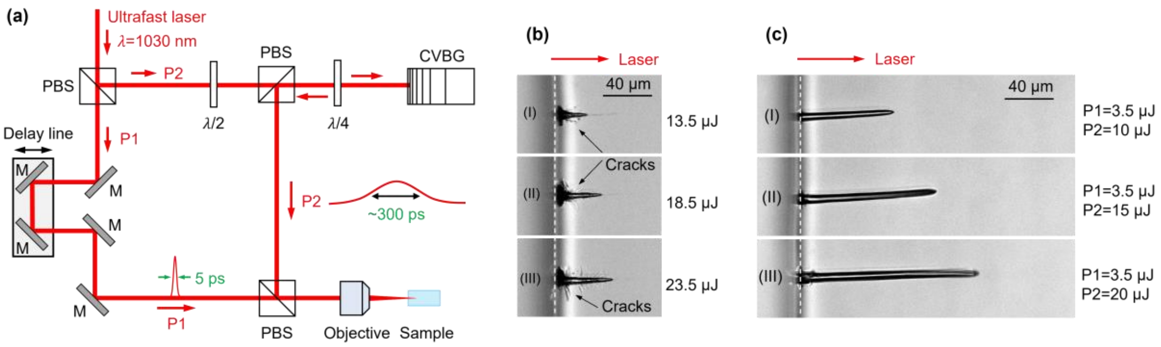

Fig. 1 (a) Experimental setup. PBS: polarizing beam splitter; CVBG: chirped volume Bragg grating; M: mirror; λ/2: half waveplate; λ/4: quarter waveplate. (b) Conventional method. (c) Proposed method.

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