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(54) Title: TRANSPARENT MATERIAL PROCESSING WITH AN ULTRASHORT PULSE LASER

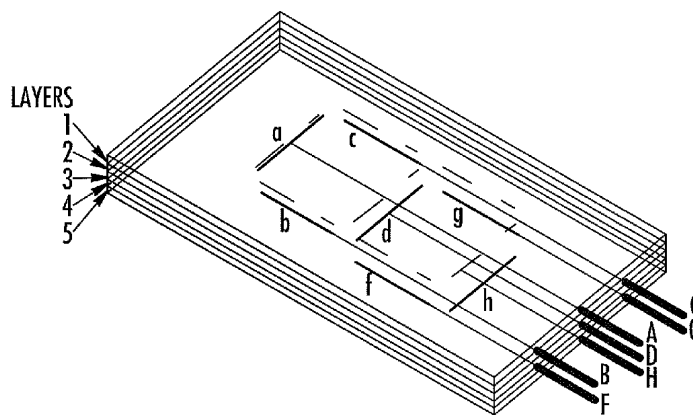


FIG. 15

(57) Abstract: Methods, devices, and systems for ultrashort pulse laser processing of optically transparent materials are disclosed, with example applications in scribing, marking, welding, and joining. For example, ultrashort laser pulses create scribe features with one pass of the laser beam across the material, with at least one of the scribe features being formed below the surface of the material. Slightly modifying the ultrashort pulse laser processing conditions produces sub-surface marks. When properly arranged, these marks are clearly visible with correctly aligned illumination. Reflective marks may also be formed with control of laser parameters. A transparent material other than glass may be utilized. A method for welding transparent materials uses ultrashort laser pulses to create a bond through localized heating. In some embodiments of transparent material processing, a multifocus beam generator simultaneously forms multiple beam waists spaced depthwise relative to the transparent material, thereby increasing processing speed.



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## A. CLASSIFICATION OF SUBJECT MATTER

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According to International Patent Classification (IPC) or to both national classification and IPC

## B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

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Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

USPC - 219/121.61, 121.69; 372/9

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

Electronic Databases Searched: PubWEST(PGPB,USPT,USOC,EPAB,JPAB); Google Scholar

Search Terms Used: laser, beam, pulse, roughness, transparent, ultra-short, scatter, scan, beam splitter, beam combiner

## C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X --- Y	US 2007/0051706 A1 (Bovatssek et al.) 08 March 2007 (08.03.2007), entire document, especially, FIG. 3, para. [0075], [0081], [0107]	1-3, 6, 7, 9, 17, 20, 22-25, 27-43, 46-49, 51, 53, 55-59, 62, 63
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Y	US 5,972,816 A (Goto) 26 October 1999 (26.10.1999), co. 15, ln. 21-41	21
		26, 44, 45

 Further documents are listed in the continuation of Box C.

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C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT		
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