CLAIMS

1. A method of laser processing a material comprising:

focusing a pulsed laser beam into a laser beam focal line;

directing the laser beam focal line into the material at a first location, the laser beam focal line generating an induced absorption within the material, the induced absorption producing a damage track along the laser beam focal line within the material;

translating the material and the pulsed laser beam relative to each other starting from the first location along a first closed contour, thereby producing a plurality of damage tracks along the first closed contour within the material; and

directing a focused $CO_2$ laser into the material around a second closed contour contained within the first closed contour to facilitate removal of an inner plug of the material along the first closed contour.

2. The method of claim 1, further comprising:

directing the laser beam focal line into the material at a second location, the laser beam focal line generating an induced absorption within the material, the induced absorption producing a damage track along the laser beam focal line within the material at the second location; and

translating the material and the pulsed laser beam relative to each other starting from the second location along a third closed contour, thereby producing a plurality of damage tracks along the third closed contour within the material, the third closed contour contained within the first closed contour, wherein directing the laser beam focal line into the material at the second location and translating the material and the pulsed laser beam relative to each other along the third closed contour each occur before directing the focused $CO_2$ laser into the material around the second closed contour contained within the first closed contour.

3. The method of claim 2, wherein the second closed contour is contained between the first closed contour and the third closed contour.

4. The method of any one of claims 1 to 3, further comprising directing an assist gas toward the material and collinear with the $CO_2$ laser beam.

5. The method of any one of claims 1 to 4, wherein removal of the inner plug defines an opening in the material, the opening comprising a width between 0.5 mm and 100 mm.

6. The method of claim 5, wherein a depth of subsurface damage along an edge surface of the opening is less than or equal to 75 μm within the material.

7. The method of claim 6, wherein an Ra surface roughness along the edge surface is less than or equal to 0.5 μm.

8. The method of any one of claims 1 to 7, wherein the material and the pulsed laser beam are translated relative to each other at a speed in a range between 1 mm/sec and 3400 mm/sec.

9. The method of any one of claims 1 to 8, wherein a pulse duration of the pulsed laser beam is in a range between greater than 1 picosecond and less than 100 picoseconds.

10. The method of any one of claims 1 to 9, wherein a repetition rate of the pulsed laser beam is in a range between 1 kHz and 2 MHz.

11. The method of claim 1, wherein pulses of the pulsed laser beam are produced in pulse bursts of at least two pulses separated by a duration in a range between 1 nsec and 50 nsec, and a pulse burst repetition frequency of the pulsed laser beam is in a range between 1 kHz and 650 kHz.

12. The method of claim 1, wherein the pulsed laser beam produces pulse bursts comprising an energy per burst measured at the material greater than 40 μJ per mm thickness of the material.

13. The method of any one of claims 1 to 12, wherein the laser beam focal line comprises a length in a range of between 0.1 mm and 100 mm.

14. A glass article made by the method of claim 7, wherein:

the glass article comprises an opening in the glass material, the opening comprising a width between 0.5 mm and 100 mm;

a depth of subsurface damage along an edge of the opening is less than or equal to 75 μm within the glass material; and

an Ra surface roughness along the edge surface is less than or equal to 0.5 μm.

15. The glass article of claim 14, wherein the glass article comprises ion exchanged glass.