workpiece 102. For example, the third positioner 110 may include a Y-stage for imparting movement of the workpiece 102 along the Y-direction and an X-stage for imparting movement of the scan head along the X-direction. Some examples of split-axis positioning systems that may be beneficially or advantageously employed in the apparatus 100 include any of those disclosed in U.S. Patent Nos. 5,751,585, 5,798,927, 5,847,960, 6,606,999, 7,605,343, 8,680,430, 8,847,113, or in U.S. Patent App. Pub. No. 2014/0083983, or any combination thereof, each of which is incorporated herein by reference in its entirety.

In one embodiment in which the third positioner 110 includes a Z-stage, the Z-stage may be arranged and configured to move the workpiece 102 along the Z-direction. In this case, the Z-stage may be carried by one or more of the other aforementioned stages for moving or positioning the workpiece 102, may carry one or more of the other aforementioned stages for moving or positioning the workpiece 102, or any combination thereof. In another embodiment in which the third positioner 110 includes a Z-stage, the Z-stage may be arranged and configured to move the scan head along the Z-direction. Thus, in the case where the third positioner 110 is provided as a split-stage positioning system, the Z-stage may carry, or be carried by, the X-stage. Moving the workpiece 102 or the scan head along the Z-direction can result in a change in spot size at the workpiece 102.

In still another embodiment, one or more components such as the first positioner 106, second positioner 108, scan lens 112, etc., may be carried by an articulated, multi-axis robotic arm (e.g., a 2-, 3-, 4-, 5-, or 6-axis arm). In such an embodiment, the second positioner 108 and/or scan lens 112 may, optionally, be carried by an end effector of the robotic arm. In yet another embodiment, the workpiece 102 may be carried directly on an end effector of an articulated, multi-axis robotic arm (i.e., without the third positioner 110). In still another embodiment, the third positioner 110 may be carried on an end effector of an articulated, multi-axis robotic arm.

E. Scan Lens

The scan lens 112 (e.g., provided as either a simple lens, or a compound lens) is generally configured to focus the beam of laser energy directed along the beam path, typically so as to produce a beam waist that can be positioned at or near the desired process spot. The scan lens 112 may be provided as an non-telecentric f-theta lens (as shown), a telecentric f-theta lens, an

WHAT IS CLAIMED IS:

1. A method of forming an opening within a metallic structure of a workpiece comprising a dielectric structure and the metallic structure on the dielectric structure, wherein the opening formed in the metallic structure exposes a portion of the dielectric structure, the method comprising:

scanning a beam of laser energy directed onto the workpiece such that the beam of laser energy is incident upon the metallic structure, wherein the scanning includes addressing, in sequence, a plurality spot locations of a scan pattern by delivering the laser energy to each of the plurality of spot locations such that a distance between spot locations in pairs of consecutively-addressed spot locations of the plurality of spot locations is greater than a distance between spot locations in pairs of spatially-adjacent spot locations;

during scanning of the laser energy, heating a region of the metallic structure and vaporizing the dielectric structure adjacent to the heated region of the metallic structure; and

ejecting the heated region of the metallic structure from the workpiece under the influence of a pressure of the vaporized dielectric structure only after all spot locations of the plurality of spot locations have been addressed.

2. The method of claim 1, wherein the laser energy has a wavelength in the infrared range of the electromagnetic spectrum.

3. The method of claim 1, wherein the laser energy has a wavelength in the ultraviolet range of the electromagnetic spectrum.

4. The method of claim 1, wherein scanning the beam of laser energy includes delivering at least one laser pulse to each of the plurality of spot locations.

5. The method of claim 4, wherein scanning the beam of laser energy includes delivering only one laser pulse to at least one of the plurality of spot locations.

6. The method of claim 1, wherein scanning the beam of laser energy to deliver the laser energy comprises:

generating, at a laser source, a first laser pulse; and

temporally dividing the first laser pulse into a plurality of second laser pulses, wherein at least two of the plurality of second laser pulses have different pulse durations.

7. The method of claim 1, wherein scanning the beam of laser energy to deliver the laser energy comprises:

generating, at a laser source, a first laser pulse; and

temporally dividing the first laser pulse into a plurality of second laser pulses, wherein at least two of the plurality of second laser pulses have the same pulse duration.

8. The method of claim 6 or claim 7, wherein the pulse duration of at least one of the plurality of second laser pulses is less than or equal to 1 μs.

9. The method of claim 6 or claim 7, wherein at least two of the plurality of second laser pulses have different peak powers.

10. The method of claim 6 or claim 7, wherein at least two of the plurality of second laser pulses have the same peak power.

11. The method of claim 6 or claim 7, wherein temporally dividing the first laser pulse comprises diffracting the first laser pulse.

12. The method of claim 1, wherein delivering the laser energy, in sequence, to the plurality of spatially different spot locations of the scan pattern includes delivering the laser energy to a different spot location at a rate greater than or equal to 20 kHz.

13. The method of claim 12, wherein the rate is greater than or equal to 1 MHz.

14. The method of claim 1, wherein

a portion of the first structure is melted when the first structure is ejected from the workpiece.

15. The method of claim 14, wherein another portion of the first structure is unmelted when the first structure ejected from the workpiece, wherein the unmelted portion is surrounded by the melted portion.

16. An apparatus for forming a feature within a workpiece comprising a first structure and a second structure, wherein the feature includes an opening formed in the first structure, the apparatus comprising:

a laser source operative to generate a beam of laser energy, wherein the beam of laser energy is propagatable along a beam path to be incident upon the first structure of the workpiece;

a positioner operative to deflect the beam path; and

a controller communicatively coupled to the positioner, wherein the controller is configured to control an operation of the positioner to effect a scanning process as recited in claim 1.

17. A controller for use with an apparatus for forming a feature within a workpiece comprising a first structure and a second structure, wherein the feature includes an opening formed in the first structure and wherein the apparatus includes a laser source operative to generate a beam of laser energy, wherein the beam of laser energy is propagatable along a beam path to be incident upon the first structure of the workpiece, and a positioner operative to deflect the beam path, the controller comprising:

a processor communicatively coupled to the positioner; and

memory accessible to the processor, wherein the memory has instructions stored thereon which, when executed by the processor, cause the processor to control an operation of the positioner to effect a scanning process as recited in claim 1.

18. A non-transitory computer-readable medium for use with an apparatus for forming a feature within a workpiece comprising a first structure and a second structure, wherein the feature includes an opening formed in the first structure and wherein the apparatus includes a laser source operative to generate a beam of laser energy, wherein the beam of laser energy is propagatable along a beam path to be incident upon the first structure of the workpiece, a positioner operative to deflect the beam path, and a controller operative to control an operation of

the positioner, the non-transitory computer-readable medium having stored thereon instructions which, when executed by the controller, cause the controller to carry out the method recited in claim 1.

19. The method of claim 1, wherein the laser energy has a wavelength in the green range of the electromagnetic spectrum.

20. The method of claim 1, further comprising directing the beam of laser energy such that, during the scanning, the laser energy is continuously directed onto the workpiece over a period of time when spot locations of at least one pair of consecutively-addressed spot locations are addressed.