DEVICES, SYSTEMS, AND METHODS FOR MULTI-PROJECTOR THREE DIMENSIONAL PRINTING

CROSS-REFERENCES

[0001] This utility patent application claims the benefit of priority to U.S. Provisional Patent Application No. 62/826,361, filed on March 29, 2019, entitled METHOD AND SYSTEM FOR METHODOLOGIES AND HARDWARE FOR MULTI-PROJECTOR THREE DIMENSIONAL PRINTING, the contents of which are incorporated herein by reference, in their entirety.

SUMMARY

[0002] Disclosed embodiments relate to devices, systems, and methodologies for three dimensional printing, for example, additive manufacturing, which can include a StereoLithographic Approach (SLA) and/or Digital Light Patterning (DLP) for three dimensional printing.

[0002a] According to a first aspect, there is provided a patterning module for an additive manufacturing system as part of an array of patterning modules under common control by a controller that is remote to the array of patterning modules, the patterning module including: a micro-projector configured to project energy for performing energy patterning for additive manufacturing; and a multi-axis micro-positioning system to control x-direction, y-direction, and z-direction positioning of the micro-projector relative to micro-projectors of other patterning modules within the array of patterning modules, wherein the micro-positioning system includes a plurality of actuators configured to control positioning of the x-direction, y-direction, and z-direction and operated based on patterning data provided by the remote controller.

[0002b] According to a second aspect, there is provided a patterning module for an additive manufacturing system as part of an array of patterning modules under common control by a controller that is remote to the array of patterning modules, the patterning module including: a micro-projector configured to project energy for performing energy patterning for additive manufacturing; a multi-axis micro-positioning system to control positioning of the micro-projector relative to micro-projectors of other patterning modules within the array of patterning modules, wherein the micro-positioning system includes a plurality of actuators operated based on patterning data provided by the remote controller, and a micro-computer arranged in communication with at least one of the micro-projector and the multi-axis micro-positioning system for receiving control commands including the patterning data from the remote controller for controlling operation of at least one of the micro-projector and the multi-axis micro-positioning system, wherein communications between the micro- computer and remote controller are encrypted.

[0002c] According to a third aspect, there is provided an additive manufacturing device including: a device controller; and an array of patterning modules under common control of the

device controller, wherein the device controller is arranged remote relative to the patterning module array, wherein each of the patterning modules within the array includes: a micro-projector configured to project energy for performing energy patterning for additive manufacturing; a multi-axis micro-positioning system to control positioning of the micro-projector relative to micro-projectors of other patterning modules of the array of patterning modules, wherein the micro-positioning system includes a plurality of actuators operated based on patterning data provided by the device controller; and a micro-computer in communication with at least one of the corresponding micro-projector and the corresponding multi-axis micro-positioning system, the micro-computer including memory storage and arranged for receiving and storing patterning data from the device controller for controlling operation of at least one of the corresponding micro-projector and multi-axis micro- positioning system.

[0002d] According to a fourth aspect, there is provided a method of performing additive manufacturing including: controlling emission of projected energy by an array of a plurality of patterning modules by a device controller that is remote to the patterning module array, wherein each of the patterning modules within the array includes a micro-projector configured to project energy for performing energy patterning; and controlling positioning of the micro-projector in the x-direction, y-direction, and z-direction relative to micro-projectors included in other patterning modules within the patterning module array using a multi-axis, micro-positioning system configured to control positioning of the x-direction, y-direction, and z-direction, wherein the micro-positioning system includes a plurality of actuators operated based on instructions provided by the remote device controller.

[0003] In accordance with at least some disclosed embodiments, an array of energy patterning (e.g., light patterning) modules may be used in a 3D printing methodology.

[0004] In accordance with at least some disclosed embodiments, each patterning module may include a multi-axis, micro-positioning system operating in conjunction with an energy patterning system including a projector.

[0005] In accordance with at least some disclosed embodiments, the projection system and/or micro-positioner may participate in a feed-back control loop for automated alignment of the energy patterning system to generate a continuous display area.

[0006] In accordance with at least some disclosed embodiments, each patterning module may contain an on-board micro-computer which is responsible for receiving and distributing commands to the energy patterning system and/or the micro-positioning system from a local or remote host. The communication between the micro-computer and the host may be (i) wired or wireless, (ii) encrypted, and (iii) bi-directional.

[0007] In accordance with at least some disclosed embodiments, the micro-computer may receive commands/data which are sent to the patterning module to control energy output (both pattern and intensity) of the projection of the energy patterning system. The micro-positioner may receive commands/data which are used to adjust the location of the patterning module along with the projector within the patterning module.

CLAIMS

1. A patterning module for an additive manufacturing system as part of an array of patterning modules under common control by a controller that is remote to the array of patterning modules, the patterning module comprising:

a micro-projector configured to project energy for performing energy patterning for additive manufacturing; and

a multi-axis micro-positioning system to control x-direction, y-direction, and z-direction positioning of the micro-projector relative to micro-projectors of other patterning modules within the array of patterning modules,

wherein the micro-positioning system includes a plurality of actuators configured to control positioning of the x-direction, y-direction, and z-direction and operated based on patterning data provided by the remote controller.

2. The patterning module of claim 1, wherein the multi-axis micro-positioning system implements positioning of the micro-projector relative to micro-projectors of other patterning modules of the array to align fields-of-view for the micro-projectors of the array to generate a continuous display area.

3. The patterning module of claim 2, wherein the multi-axis micro-positioning system implements positioning of the micro-projector according to automated control commands from the remote controller to automatically align a field-of-view of the micro-projector with at least one field-of-view of the other patterning modules of the array.

4. The patterning module of claim 3, wherein the remote controller is arranged in communication with at least one sensor for collecting data to determine a relative position of one or more of the other patterning modules for aligning the field of view of the micro-projector with the micro-projector of at least one other patterning module of the array.

5. The patterning module of claim 3, wherein automated control commands for the multi-axis micro-positioning system are generated by the remote controller using feed-back control information considering at least one of the micro-projector and the micro-positioning system.

6. The patterning module of claim 1, further comprising a micro-computer arranged in communication with at least one of the micro-projector and the multi-axis micro-positioning system for receiving control commands including the patterning data from the remote controller for controlling operation of at least one of the micro-projector and the multi-axis micro-positioning system.

7. The patterning module of claim 6, wherein the patterning data received by micro-computer from the remote controller includes positional commands for the multi-axis micropositioner.

8. The patterning module of claim 6, wherein the patterning data received by micro-computer from the remote controller includes a projection data set to be projected by the micro-projector for additive manufacturing.

9. A patterning module for an additive manufacturing system as part of an array of patterning modules under common control by a controller that is remote to the array of patterning modules, the patterning module comprising:

a micro-projector configured to project energy for performing energy patterning for additive manufacturing;

a multi-axis micro-positioning system to control positioning of the micro-projector relative to micro-projectors of other patterning modules within the array of patterning modules, wherein the micro-positioning system includes a plurality of actuators operated based on patterning data provided by the remote controller, and

a micro-computer arranged in communication with at least one of the micro-projector and the multi-axis micro-positioning system for receiving control commands including the patterning data from the remote controller for controlling operation of at least one of the micro-projector and the multi-axis micro-positioning system,

wherein communications between the micro- computer and remote controller are encrypted.

10. The patterning module of claim 9, wherein encryption of the communications between the micro-computer and the remote controller includes encryption of vector strings sent to an address associated with the patterning module.

11. The patterning module of claim 10, wherein encryption includes application of symmetric encryption cypher.

12. The patterning module of claim 9, wherein encryption includes application of one or more of cypher keys and token specific to the additive manufacturing system.

13. The patterning module of claim 9, wherein encryption includes scrambling of at least one of x-y image plane data and z-image stack based upon at least one of data buffering frequency and data transmission speeds.

14. An additive manufacturing device comprising:

a device controller; and

an array of patterning modules under common control of the device controller, wherein the device controller is arranged remote relative to the patterning module array,

wherein each of the patterning modules within the array comprises:

a micro-projector configured to project energy for performing energy patterning for additive manufacturing;

a multi-axis micro-positioning system to control positioning of the micro-projector relative to micro-projectors of other patterning modules of the array of patterning modules, wherein the micro-positioning system includes a plurality of actuators operated based on patterning data provided by the device controller; and

a micro-computer in communication with at least one of the corresponding micro-projector and the corresponding multi-axis micro-positioning system, the micro-computer including memory storage and arranged for receiving and storing patterning data from the device controller for controlling operation of at least one of the corresponding micro-projector and multi-axis micro- positioning system.

15. The additive manufacturing device of claim 14, wherein the micro-computer is arranged for receiving and storing projection patterning data from the device controller and is in communication with the corresponding micro-projector for controlling operation of the micro-projector.

16. The additive manufacturing device of claim 14, wherein the multi-axis micro-positioning system implements positioning of one or more of the micro-projectors relative to at least one micro-projector of other patterning modules of the array to align fields-of-view for the micro-projectors of the array to generate a continuous display area.

17. The additive manufacturing device of claim 16, wherein the multi-axis micro-positioning system implements positioning of the one or more micro-projectors according to automated control commands from the remote controller to automatically align fields-of-view for the micro-projectors of the array.

18. The additive manufacturing device of claim 17, further comprising at least one sensor for collecting data, the at least one sensor arranged in communication with the device controller for determining relative location of one or more of the patterning modules for aligning one or more fields-of-view of the micro-projectors of the array.

19. The additive manufacturing device of claim 18, wherein automated control commands for the multi-axis micro-positioning system are generated by the remote controller using feed-back control information considering at least one of the micro-projector and the micro-positioning system.

20. The additive manufacturing device of claim 15, wherein the patterning data received and stored by at least one micro-computer from the remote controller includes positional commands for the multi-axis micropositioner.

21. The additive manufacturing device of claim 15, wherein the patterning data received and stored by at least one micro-computer from the remote controller includes a projection data set to be projected by the micro-projector.

22. The additive manufacturing device of claim 14, wherein the communications between one or more of the micro-computers and remote device controller are encrypted.

23. The additive manufacturing device of claim 22, wherein encryption includes encryption of vector strings sent to an address associated with the patterning module.

24. The additive manufacturing device of claim 23, wherein encryption includes application of symmetric encryption cypher.

25. The additive manufacturing device of claim 22, wherein encryption includes application of one or more cypher keys specific to the additive manufacturing system.

26. The additive manufacturing device of claim 22, wherein encryption includes scrambling of at least one of x-y image plane data and z-image stack based upon at least one of data buffering frequency and data transmission speeds.

27. The additive manufacturing device of claim 14, wherein the patterning data includes synchronization data for synchronizing projection between different modules of the array.

28. The additive manufacturing device of claim 14, further comprising a base mount configured to receive mounting of one or more patterning modules of the array.

29. The additive manufacturing device of claim 28, wherein the base mount includes a number of connection ports, each connection port for communication with one of the patterning modules mounted on the base mount.

30. The patterning module of claim 1, wherein the patterning data includes synchronization data for synchronizing projection between different patterning modules of the array.

31. The patterning module of claim 1, wherein the field of view of the patterning module is larger than a footprint of the patterning module.

32. The additive manufacturing device of claim 14, wherein a field of view of at least one of the patterning modules of the array is larger than a footprint of the at least one patterning module.

33. A method of performing additive manufacturing comprising:

controlling emission of projected energy by an array of a plurality of patterning modules

by a device controller that is remote to the patterning module array, wherein each of the patterning modules within the array includes a micro-projector configured to project energy for performing energy patterning; and

controlling positioning of the micro-projector in the x-direction, y-direction, and z-direction relative to micro-projectors included in other patterning modules within the patterning module array using a multi-axis, micro-positioning system configured to control positioning of the x-direction, y-direction, and z-direction, wherein the micro-positioning system includes a plurality of actuators operated based on instructions provided by the remote device controller.

34. The method of claim 33, further comprising relaying data received from the remote device controller by a micro-computer coupled to the micro-projector and/or the multi-axis, micro-positioning system to either the micro-projector or multi-axis micro-positioning system.

35. The method of claim 34, further comprising encrypting the data sent between the micro-computer and remote device controller.

36. The method of claim 35, wherein the multi-axis, micro-positioning system automatically controls positioning of the micro-projector relative to micro-projectors included in other patterning modules within the patterning module array so as to automatically align fields-of-view for the micro-projectors of the patterning module array to generate a continuous display area.

37. The method of claim 36, further comprising collecting data using a sensory element to determine the relative location of the patterning modules to provide alignment of the field of view of the micro-projector with a micro-projector of at least one other patterning module in the array.

38. The method of claim 36, wherein the control of the multi-axis, micro-positioning system is performed using a feed-back loop that includes the micro-projector and/or the micro-positioner.