anomalies by comparing interferometric images of the test object under a loaded state of acoustic wave excitation with that of an unloaded state. Large area, non-contact and non-destructive inspection of defects can be performed by steering the laser pulses across the test object.

[0013] An aspect of the present disclosure provides a non-contact non-destructive testing method comprising:

spatially and temporally controlling a laser excitation light based on a predetermined pattern, the laser excitation light being generated from a plurality of pulsed lasers;

projecting the laser excitation light onto a surface of a test object to generate acoustic waves on the test object, the acoustic wave applying stress loading to the test object;

imaging the test object with and without stress loading using shearography imaging; and

analyzing shearography imaging data to determine a presence of a defect in the test object.

[0014] Spatially controlling the laser excitation light may comprise shaping the laser excitation light into a geometric pattern comprising at least one continuous straight line for generating directional acoustic waves.

[0015] The method may further comprise rotating the at least one continuous straight line to steer the acoustic waves.

[0016] The geometric pattern may comprise a plurality of straight lines, and a gap between adjacent straight lines may be selected based on a wavelength of the acoustic waves to be generated.

[0017] Spatially controlling the laser excitation light may comprise shaping the laser excitation light into a geometric pattern comprising at least one continuous curved line for generating focused acoustic waves, and a focus point of the acoustic waves may coincide with the focus point of a curvature of the at least one continuous curved line.

[0018] The geometric pattern may comprise a plurality of curved lines, and a gap between adjacent curved lines may be selected based on a wavelength of the acoustic waves to be generated.

[0019] Spatially controlling the laser excitation light may comprise shaping the laser excitation light into a geometric pattern comprising at least one enclosed line shape for generating focused acoustic waves.

[0020] The geometric pattern may comprise a plurality of enclosed line shapes, and a gap between adjacent enclosed line shapes may be selected based on a wavelength of the acoustic waves to be generated.

[0021] The at least one enclosed line shape may comprise one of a group consisting of a circle, a polygon, and an oval.

[0022] Spatially controlling the laser excitation light may comprise shaping the laser excitation light into a geometric pattern comprising a dotted line, the dotted line being selected from a group consisting of a dotted straight line, a dotted curved line, and a dotted enclosed line shape.

[0023] The method may further comprise projecting the laser excitation light onto a plurality of locations on the surface of the test object and determining the presence of a defect in a corresponding plurality of regions of the test object.

[0024] Temporally controlling the laser excitation light may comprise selecting a pulse duration of the pulsed lasers based on a material of the test object and/or a frequency of the acoustic waves.

[0025] Temporally controlling the laser excitation light may further comprise synchronizing the plurality of pulsed lasers to emit simultaneously.

[0026] Temporally controlling the laser excitation light may further comprise controlling the plurality of pulsed lasers to emit sequentially based on predetermined time delays.

[0027] Imaging the test object may comprise:

illuminating a region on the surface of test object with a laser illumination light;

for each loading state, recording a respective interferometric speckle pattern generated by reflected laser illumination light using an image sensor.

[0028] Another aspect of the present disclosure provides a non-contact non-destructive testing system comprising:

an excitation light source comprising a plurality of pulsed lasers and configured to spatially and temporally control a laser excitation light based on a predetermined pattern, and project the laser excitation light onto a surface of a test object to generate acoustic waves on the test object, wherein the acoustic waves apply stress loading to the test object; and

a shearography imaging system configured to image the test object with and without stress loading, and analyze shearography imaging data to determine a presence of a defect in the test object.

[0029] The excitation light source may be configured to spatially shape the laser excitation light into a geometric pattern comprising at least one continuous straight line for generating directional acoustic waves.

[0030] The excitation light source may be further configured to rotate the at least one continuous straight line to steer the acoustic waves.

[0031] The geometric pattern may comprise a plurality of straight lines, and a gap between adjacent straight lines may be selected based on a wavelength of the acoustic waves to be generated.

[0032] The excitation light source may be configured to spatially shape the laser excitation light into a geometric pattern comprising at least one continuous curved line for generating focused acoustic waves, and a focus point of the acoustic waves may coincide with the focus point of a curvature of the at least one continuous curved line.

[0033] The geometric pattern may comprise a plurality of curved lines, and a gap between adjacent curved lines may be selected based on a wavelength of the acoustic waves to be generated.

[0034] The excitation light source may be configured to spatially shape the laser excitation light into a geometric pattern comprising at least one enclosed line shape for generating focused acoustic waves.

[0035] The geometric pattern may comprise a plurality of enclosed line shapes, and a gap between adjacent enclosed line shapes may be selected based on a wavelength of the acoustic waves to be generated.

[0036] The at least one enclosed line shape may comprise one of a group consisting of a circle, a polygon, and an oval.

[0037] The excitation light source may be configured to spatially shape the laser excitation light into a geometric pattern comprising a dotted line, the dotted line being selected from a group consisting of a dotted straight line, a dotted curved line, and a dotted enclosed line shape.

[0038] The excitation light source may be further configured to project the laser excitation light onto a plurality of locations on the surface of the test object and the shearography imaging system may be further configured to determine the presence of a defect in a corresponding plurality of regions of the test object.

[0039] A pulse duration of the pulsed lasers may be selected based on a material of the test object and/or a frequency of the acoustic waves.

[0040] The plurality of pulsed lasers may be temporally synchronized to emit simultaneously.

[0041] The plurality of pulsed lasers may be temporally controlled to emit sequentially based on predetermined time delays.

[0042] The shearography imaging system may comprise:

an illumination light source configured to illuminate a region on the surface of test object with laser illumination light; and

an image sensor configured to record, for each loading state, a respective interferometric speckle pattern generated by reflected laser illumination light.

CLAIMS

1. A non-contact non-destructive testing method comprising:

spatially and temporally controlling a laser excitation light based on a predetermined pattern, the laser excitation light being generated from a plurality of pulsed lasers;

projecting the laser excitation light onto a surface of a test object to generate acoustic waves on the test object, the acoustic waves applying stress loading to the test object;

imaging the test object with and without stress loading using shearography imaging; and

analyzing shearography imaging data to determine a presence of a defect in the test object.

2. The method as claimed in claim 1, wherein spatially controlling the laser excitation light comprises shaping the laser excitation light into a geometric pattern comprising at least one continuous straight line for generating directional acoustic waves.

3. The method as claimed in claim 2, further comprising rotating the at least one continuous straight line to steer the acoustic waves.

4. The method as claimed in claim 2 or 3, wherein the geometric pattern comprises a plurality of straight lines, and wherein a gap between adjacent straight lines is selected based on a wavelength of the acoustic waves to be generated.

5. The method as claimed in claim 1, wherein spatially controlling the laser excitation light comprises shaping the laser excitation light into a geometric pattern comprising at least one continuous curved line for generating focused acoustic waves, and wherein a focus point of the acoustic waves coincides with the focus point of a curvature of the at least one continuous curved line.

6. The method as claimed in claim 5, wherein the geometric pattern comprises a plurality of curved lines, and wherein a gap between adjacent curved lines is selected based on a wavelength of the acoustic waves to be generated.

7. The method as claimed in claim 1, wherein spatially controlling the laser excitation light comprises shaping the laser excitation light into a geometric pattern comprising at least one enclosed line shape for generating focused acoustic waves.

8. The method as claimed in claim 7, wherein the geometric pattern comprises a plurality of enclosed line shapes, and wherein a gap between adjacent enclosed line shapes is selected based on a wavelength of the acoustic waves to be generated.

9. The method as claimed in claim 7 or 8, wherein the at least one enclosed line shape comprises one of a group consisting of a circle, a polygon, and an oval.

10. The method as claimed in claim 1, wherein spatially controlling the laser excitation light comprises shaping the laser excitation light into a geometric pattern comprising a dotted line, the dotted line being selected from a group consisting of a dotted straight line, a dotted curved line, and a dotted enclosed line shape.

11. The method as claimed in any one of the preceding claims, further comprising projecting the laser excitation light onto a plurality of locations on the surface of the test object and determining the presence of a defect in a corresponding plurality of regions of the test object.

12. The method as claimed in any one of the preceding claims, wherein temporally controlling the laser excitation light comprises selecting a pulse duration of the pulsed lasers based on a material of the test object and/or a frequency of the acoustic waves.

13. The method as claimed in claim 12, wherein temporally controlling the laser excitation light further comprises synchronizing the plurality of pulsed lasers to emit simultaneously.

14. The method as claimed in claim 12, wherein temporally controlling the laser excitation light further comprises controlling the plurality of pulsed lasers to emit sequentially based on predetermined time delays.

15. The method as claimed in any one of the preceding claims, wherein imaging the test object comprises:

illuminating a region on the surface of test object with a laser illumination light;

for each loading state, recording a respective interferometric speckle pattern generated by reflected laser illumination light using an image sensor.

16. A non-contact non-destructive testing system comprising:

an excitation light source comprising a plurality of pulsed lasers and configured to spatially and temporally control a laser excitation light based on a predetermined pattern, and project the laser excitation light onto a surface of a test object to generate acoustic waves on the test object, wherein the acoustic waves apply stress loading to the test object; and

a shearography imaging system configured to image the test object with and without stress loading, and analyze shearography imaging data to determine a presence of a defect in the test object.

17. The system as claimed in claim 16, wherein the excitation light source is configured to spatially shape the laser excitation light into a geometric pattern comprising at least one continuous straight line for generating directional acoustic waves.

18. The system as claimed in claim 17, wherein the excitation light source is further configured to rotate the at least one continuous straight line to steer the acoustic waves.

19. The system as claimed in claim 17 or 18, wherein the geometric pattern comprises a plurality of straight lines, and wherein a gap between adjacent straight lines is selected based on a wavelength of the acoustic waves to be generated.

20. The system as claimed in claim 16, wherein the excitation light source is configured to spatially shape the laser excitation light into a geometric pattern comprising at least one continuous curved line for generating focused acoustic waves, and wherein a focus point of the acoustic waves coincides with the focus point of a curvature of the at least one continuous curved line.

21. The system as claimed in claim 20, wherein the geometric pattern comprises a plurality of curved lines, and wherein a gap between adjacent curved lines is selected based on a wavelength of the acoustic waves to be generated.

22. The system as claimed in claim 16, wherein the excitation light source is configured to spatially shape the laser excitation light into a geometric pattern comprising at least one enclosed line shape for generating focused acoustic waves.

23. The system as claimed in claim 22, wherein the geometric pattern comprises a plurality of enclosed line shapes, and wherein a gap between adjacent enclosed line shapes is selected based on a wavelength of the acoustic waves to be generated.

24. The system as claimed in claim 22 or 23, wherein the at least one enclosed line shape comprises one of a group consisting of a circle, a polygon, and an oval.

25. The system as claimed in claim 16, wherein the excitation light source is configured to spatially shape the laser excitation light into a geometric pattern comprising a dotted line, the dotted line being selected from a group consisting of a dotted straight line, a dotted curved line, and a dotted enclosed line shape.

26. The system as claimed in any one of claims 16 to 25, wherein the excitation light source is further configured to project the laser excitation light onto a plurality of locations on the surface of the test object and the shearography imaging system is further configured to determine the presence of a defect in a corresponding plurality of regions of the test object.

27. The system as claimed in any one of claims 16 to 26, wherein a pulse duration of the pulsed lasers is selected based on a material of the test object and/or a frequency of the acoustic waves.

28. The system as claimed in claim 27, wherein the plurality of pulsed lasers are temporally synchronized to emit simultaneously.

29. The system as claimed in claim 27, wherein the plurality of pulsed lasers are temporally controlled to emit sequentially based on predetermined time delays.

30. The system as claimed in any one of claims 16 to 29, wherein the shearography imaging system comprises:

an illumination light source configured to illuminate a region on the surface of test object with laser illumination light; and

an image sensor configured to record, for each loading state, a respective interferometric speckle pattern generated by reflected laser illumination light.