

CLAIMS

What is claimed is:

1. A system comprising:
a material processing system including a processing beam source for generating a processing beam and a processing beam head for delivering the processing beam to a target;
a coherence imaging (CI) measurement system including a coherence imaging (CI) core unit for generating a measurement beam and a CI scan module for delivering the measurement beam to the target, wherein the CI measurement system produces a CI measurement output; and
at least one controller configured to receive the CI measurement output from the CI core unit for monitoring and/or controlling the material processing system, wherein the controller is also configured to receive a calibration measurement output and to control the CI measurement system based, at least in part, on the calibration measurement output, wherein the controller is configured to control the CI measurement system to modify future measurements made by the CI measurement system for alignment of the CI measurement system and the processing beam.
2. The system of claim 1 wherein the CI measurement system produces the calibration measurement output, and wherein an interferometry output from the CI measurement system is used as the contrast mechanism to produce the calibration measurement output from the CI measurement system.
3. The system of claim 1 wherein the CI measurement system produces the calibration measurement output, and wherein process radiation produced by the processing beam is used as the contrast mechanism to produce the calibration output from the CI measurement system.
4. The system of claim 1 further including a 2D inline camera coupled to the processing head, and wherein the 2D inline camera generates image data used to produce the calibration measurement output.

5. The system of claim 4 wherein the 2D inline camera shares an optical path with the CI measurement system, and wherein back reflected light is split between the 2D inline camera and the CI measurement system.
6. The system of claim 1 further including a double clad fiber coupled to the CI core unit and to a photodetector, wherein the double clad fiber is configured to transmit process radiation to the photodetector and to transmit light from the measurement beam to the CI core unit.
7. The system of claim 6 wherein the calibration measurement output is produced by the photodetector.
8. The system of claim 1 further including a 2D camera positioned proximate the target, and wherein the 2D camera generates image data used to produce the calibration measurement output.
9. The system of claim 1 wherein the material processing system includes a laser processing system.
10. The system of claim 9 wherein the laser processing system includes a laser with an output substantially of a single spatial mode with an M-squared value of less than 2.0.
11. The system of claim 1 wherein the CI measurement system includes an inline coherent imaging (ICI) system.
12. A method for calibrating a coherence imaging (CI) measurement system, comprising:
 - providing a material processing system configured to generate and deliver a processing beam to a target;
 - providing a coherence imaging (CI) measurement system configured to generate and deliver a measurement beam to the target and configured to provide a CI measurement system output for controlling and/or monitoring the material processing system;
 - obtaining a calibration measurement output from the CI measurement system and/or from an auxiliary sensor; and

automatically controlling the CI measurement system based on, at least in part, the calibration measurement output, wherein the CI measurement system is controlled to modify future measurements made by the CI measurement system for alignment of the CI measurement system and the processing beam.

13. The method of claim 12 wherein the calibration measurement output is provided by the CI measurement system using an interferometry output of the CI measurement system as a contrast mechanism.

14. The method of claim 13 wherein obtaining the calibration measurement output comprises:

at least temporarily producing a physical modification on the target using the processing beam;

obtaining a measurement of the physical modification using the CI measurement system; and

obtaining the calibration measurement output from the CI measurement system such that the physical modification corresponds to a position of the processing beam.

15. The method of claim 14 wherein obtaining the CI measurement includes scanning the measurement beam on the target proximate the physical modification in a scan pattern.

16. The method of claim 12 wherein the calibration measurement output is provided by the CI measurement system using a process emission produced by the processing beam as a contrast mechanism.

17. The method of claim 16 wherein obtaining the calibration measurement output comprises:

reducing a CI system light source to at least a negligible level;

directing the processing beam to the target;

receiving process radiation from the target into the CI measurement system when the processing beam is directed at the target; and

obtaining the calibration measurement output from the CI measurement system detecting the process radiation.

18. The method of claim 17 wherein the CI measurement system detects the process radiation while the CI measurement system is scanning the target.

19. The method of claim 17 wherein directing the processing beam includes moving the processing beam on the target and using an intensity of the detected process radiation to determine a position of the processing beam.

20. The method of claim 12 wherein the calibration measurement output is provided based on image data from a 2D inline camera coupled to the material processing system.

21. The method of claim 20 wherein obtaining the calibration measurement output comprises:

directing at least one of the processing beam and the measurement beam to the target; detecting, using the 2D inline camera, at least one of process radiation caused by the processing beam and back-reflected light from the measurement beam; and

obtaining the calibration measurement output from image data generated by the 2D inline camera detecting at least one of the process radiation and the back-reflected light from the measurement beam.

22. The method of claim 12 wherein obtaining the calibration measurement output comprises directing the processing beam to the target while pulsing at least the processing beam.

23. The method of claim 12 wherein the calibration measurement output is provided by a photodetector coupled to a double clad fiber used in the CI measurement system.

24. The method of claim 23 wherein obtaining the calibration measurement output comprises:

directing at least one of the processing beam and the measurement beam to the target;

transmitting, using the double clad fiber, process radiation to the photodetector and back reflected light from the measurement beam to the CI measurement system;
detecting the process radiation using the photodetector; and
obtaining the calibration measurement output from the photodetector detecting the process radiation.

25. The method of claim 12 wherein the calibration measurement output is provided by a 2D camera positioned proximate the target.

26. The method of claim 25 wherein obtaining the calibration measurement output comprises:

directing at least one of the processing beam and the measurement beam to the target;
detecting, using the 2D camera, at least one of process radiation caused by the processing beam and back-reflected light from the measurement beam; and
obtaining the calibration measurement output from image data generated by the 2D camera detecting at least one of the process radiation and the back-reflected light from the measurement beam.

27. The method of claim 12 wherein modifying future measurements made by the CI measurement system include at least one of modifying spatial positioning during measurement acquisition, modifying temporal synchronization during measurement acquisition, and modifying measurement algorithms.

28. The method of claim 12 wherein modifying future measurements made by the CI measurement system includes modifications to correct for optical distortions introduced by a beam delivery system in the material processing system and/or in the CI measurement system.

29. The method of claim 28 wherein modifying future measurements made by the CI measurement system includes modifications wherein optical distortions include at least one of: optical path length change, chromatic aberration, defocus, field curvature, image distortion, spherical aberration, coma, and astigmatism.

30. The method of claim 12 wherein modifying future measurements made by the CI measurement system includes modifications to correct for mechanical distortions of the material processing system and/or the CI measurement system.

31. The method of claim 30 wherein mechanical distortions include at least one of: vibrations, fit-up, torsion, extension, compression, translation, and rotation.

32. The method of claim 12 wherein modifying future measurements made by the CI measurement system includes modifications to correct for process synchronization issues selected from the group consisting of process synchronization issues include at least one of: motion control path synchronization, processing laser energy profile synchronization, workpiece distortions, process inputs, shielding gas, cover gas, process environment, process feed material, process sacrificial material, and process fixturing.

33. The method of claim 12 wherein modifying future measurements made by the CI measurement system includes modifications to correct for changes to the phase change region.