both a positioning system, in this case an XY stage 14 and a scan head 16. The overall laser processing data is represented as vector data in a global coordinate system 20 that is aligned with the positioning and galvanometer coordinate systems through appropriate coordinate transformations, and is provided to the scan controller 12. The global job coordinate system origin and laser galvanometer origin coincide with each other, while the positioning system origin and positional coordinates of the positioning system are aligned using linear transformations at run-time.

[0025] The job data is provided to two paths. In one path, the vector data is time-domain expanded 22, low-pass filtered 24, and queued for delivery to the positioning system at a reduced data rate 26. In the second path, the original job data execution is delayed 28 by the duration of the empirically derived positioning system tracking delay to allow the positioning system to start moving. The job vector data is provided at a high data rate, typically 100 KHz, for delivery to the galvanometer servos 30. Upon job start, the low-pass filtered job data is delivered to the positioning system via the positioning system controller 40 at a reduced update rate that may or may not be synchronous with the galvanometer update rate. After the positioning system tracking delay, the galvanometer data is delivered to galvanometer servos 30 at the high data rate.

[0026] The positioning system encoder data is sampled at the same rate as the galvanometer command data delivery rate and is integrated over several sample intervals to calculate the average velocity and acceleration of the positioning system 32. A position offset is calculated for the galvanometers that is proportional to the galvanometer tracking delay and the currently calculated positioning system velocity and acceleration 34. This offset is added to the galvanometer command data 36. The offset is the predictive positional bias that causes the laser to be steered to where the workpiece will be after the tracking delay. In a subsequent step, the adjusted galvanometer command data is further adjusted by subtracting the current positioning system position as measured by the positioning system encoders 38. The latter computation effectively removes the low-frequency components executed by the positioning system and results in a command that is within the addressable field of the galvanometers. The stage 14 includes the stage controller 40 as well as X axis servo 42 and Y axis servo 44, X motor 46 and Y axis motor 48 and an XY stage assembly 50. The scan head 16 includes the X axis scan head servo 52 and Y axis scan head servo 54 as well as X axis power and position feedback system 56 and Y axis power and position feedback system 58.

CLAIMS

1. A laser processing system providing on-the-fly laser processing of a workpiece, said laser processing system comprising:

a positioning system configured to support the workpiece;

a positioning system controller configured to control movement of the workpiece on the positioning system;

a scanner system including galvanometer mirrors that are configured to scan a laser beam over the workpiece; and

a scanner controller configured to operate the scanner system and the positioning system controller, said scanner controller determining a predicted path of the positioning system to move from a measured position of the positioning system during a galvanometer tracking delay interval of the galvanometer mirrors, wherein the predicted path is determined based on a velocity and an acceleration of the positioning system that are calculated by integrating observed positional changes of the positioning system over time,

said scanner controller positioning the galvanometer mirrors such that the laser beam follows the predicted path of the positioning system,

wherein the scanner controller operates the positioning system controller responsive to vector input data that is, in part, time-domain expanded and provided to the positioning system controller at a positioning system update data rate, said scanner controller operating the scanner system responsive to the vector input data that is delayed and provided to the scanning system at a galvanometer update data rate, wherein the galvanometer update data rate is higher than the positioning system update data rate.

2. The laser processing system as claimed in claim 1, wherein the positioning system update data rate and the galvanometer update data rate are synchronized.

3. The laser processing system as claimed in claim 1 or 2, wherein the vector input data that is provided by the scanner controller to the positioning system controller is further low pass filtered.

4. The laser processing system as claimed in claim 1, wherein the galvanometer update data rate being higher than the positioning system update data rate enables the scanner controller to position the galvanometer mirrors such that the laser beam follows the predicted path of the positioning system regardless of changes in velocity or position of the positioning system.

5. The laser processing system as claimed in claim 1, wherein the scanner controller calculates a position offset that is proportional to the galvanometer tracking delay interval and the velocity and the acceleration of the positioning system to determine the predicted path of the positioning system during the galvanometer tracking delay interval.

6. The laser processing system as claimed in claim 5, wherein the scanner controller adds the position offset to galvanometer command data to cause the galvanometer mirrors to steer the laser beam along the predict path of the positioning system.

7. The laser processing system as claimed in claim 1, wherein the predicted path of the positioning system is a near straight line.

8. The laser processing system as claimed in claim 1,

wherein the positioning system includes an X-axis servo, a Y-axis servo, an X-axis motor, a Y-axis motor, and an XY stage assembly, and

wherein the scanner system includes an X-axis scan head servo, a Y-axis scan head servo, an X-axis power and position feedback system, and a Y-axis power and position feedback system.

9. A method of providing on-the-fly laser processing of a workpiece, said method comprising:

providing a positioning system configured to support the workpiece;

providing a positioning system controller configured to control movement of the positioning system;

providing a scanner system including galvanometer mirrors that are configured to scan a laser beam over the workpiece;

providing a scanner controller configured to operate the scanner system and the positioning system controller;

operating the positioning system controller by the scanner controller responsive to vector input data to move the positioning system;

determining by the scanner controller a predicted path of the positioning system to move from a measured position of the positioning system during a galvanometer tracking delay interval of the galvanometer mirrors, wherein the predicted path is determined based on a velocity and an acceleration of the positioning system that are calculated by integrating observed positional changes of the positioning system over time; and

to positioning the galvanometer mirrors by the scanner controller such that the laser beam follows the predicted path of the positioning system,

wherein the scanner controller operates the positioning system controller responsive to vector input data that is, in part, time-domain expanded and provided to the positioning system controller at a positioning system update data rate, said scanner controller operating the scanner system responsive to the vector input data that is delayed and provided to the scanning system at a galvanometer update data rate, wherein the galvanometer update data rate is higher than the positioning system update data rate.

10. The method as claimed in claim 9, wherein the vector input data that is provided by the scanner controller to the positioning system controller low pass filtered.

11. The method as claimed in claim 9, wherein the scanner controller determines the predicted path of the positioning system to move from the measured position of the positioning system during the galvanometer tracking delay interval by calculating a position offset that is proportional to the galvanometer tracking delay interval and the velocity and the acceleration of the positioning system.

12. The method as claimed in claim 11, wherein the scanner controller positions the

galvanometer mirrors such that the laser beam follows the predicted path of the positioning system by adding the position offset to galvanometer command data to cause the galvanometer mirrors to steer the laser beam along the predicted path of the positioning system.

13. The method as claimed in claim 9, wherein the predicted path of the positioning system is a near straight line.