

DescriptionMethod for describing a predetermined desired course with a beam of particles or waves and use of the method

The invention relates to a method for describing a predetermined desired course with a beam of particles or waves, the direction of which beam can be modified by a movable beam-directing device. The invention also relates
5 to the use of the method.

US 5,593,606 discloses methods in which a pulsed laser beam is deflected by a motor-controlled mirror. The data of a predetermined desired course is translated by a drive device into control instructions for the motor. The
10 movable beam-directing device influences the direction of the beam, so that the latter describes, when projected onto a surface, an actual course with a velocity v_B .

These known methods have the disadvantage that, in the case of a straight-line desired course, the actual
15 course is described with a constant delay by the response error time t_s owing to the mechanical inertia of the beam-directing device. The effect of this response error is that the actual course that corresponds to a curved desired course deviates therefrom. In this case, the deviation
20 depends on the course velocity v_B . Figures 1a to 1d show various examples of these deviations. The desired course 1 and the actual course 3 for a low course velocity are represented in each case. An actual course 4 for a high course velocity is also represented in each of Figures 1b
25 and 1c.

The deviation from the desired course is commensurately greater as the course velocity with which the desired course is described increases. The effect of the deviation of the actual course from the desired course
30 is that, for a constant laser-pulse frequency, an increased

number of laser pulses are delivered onto a shortened course segment. This is represented in Figures 2a and 2b. Figure 2a represents a series of laser spots 7 along a desired course 1. The arrows thereon indicate the movement
5 direction of the laser beam. Figure 2b represents a series of laser spots 7 along the actual course. The arrows indicate the movement direction of the laser beam. If the laser beam is being used to structure a surface, then this increased pulse density can cause higher energy input per
10 area with all possible undesired consequences.

It is therefore an object of the present invention to provide a method for describing a predetermined desired course with a beam of particles or waves, in which the deviation of the actual course achieved in practice from
15 the desired course is minimized.

This object is achieved according to the invention by a method as claimed in claim 1. Advantageous configurations of the invention and uses of the invention can be found in the other claims.

20 The invention gives a method for describing a predetermined desired course with a beam of particles or waves, in which a movable beam-directing device influences the direction of the beam. The beam is directed by the beam-directing device onto a surface, on which it describes
25 an actual course with the velocity v_B . A drive device converts the desired course into a corrected desired course, which describes a diversion in the vicinity of a discrete direction change from a first direction of the desired course to a second direction of the desired course.
30 This diversion is obtained by appending and/or deleting arbitrary sections to/from the desired course. The data of the corrected desired course is translated by the drive device into control instructions for the beam-directing device.

Since the desired course to be described is already fully known prior to writing, the inventive correction of the desired course can minimize the deviations of the actual course from the desired course. Direction changes of the desired course where the desired course has corners are particularly critical for the deviations. In the vicinity of these corners, the actual course can be brought closer to the desired course by incorporating, into the desired course, diversions which extend outside the corners and compensate substantially for the undesired roundings of the actual course which are represented in Figure 1.

Correction sections which are straight-line sections are used particularly advantageously, because straight desired courses per se produce no deviations in the actual course.

In methods for describing a predetermined desired course, in which the actual course is specified with a constant course velocity v_B , a straight-line desired course is described as the actual course by the laser beam with a constant delay by the response error time t_s , owing to the mechanical inertia of the beam-directing device. In this context, the following method according to the invention for describing a predetermined desired course, which uses the response error time t_s as a basis, is particularly advantageous. The corrected desired course is then obtained from the desired course by adding a first straight-line section of length L , which points in the first direction, at the point of a direction change from a first to a second direction. For the length of this straight-line section: $L = v_B \times t_s$. Also, a second straight-line section of length L is added at the far end of the first straight-line section from the point of the direction change, the maximum possible course velocity v_{max} counter to the first direction being specified for this second straight-line section. In this case: $v_{max} > v_B$. The desired course is accordingly extended for a short distance beyond the point of the direction change. Fast return to the point of the direction change thereupon takes place.

The method as claimed in claim 1 can also be used particularly advantageously for curved desired courses, by approximating the desired course with a continuous direction change by a desired course with successive
5 discrete direction changes, which is then corrected according to the method as claimed in claim 1.

A method in which a pulsed beam is used is particularly advantageous. During the structuring of a surface by means of laser beams, for example, the problem
10 arises that an increased laser-pulse density is applied to a shortened actual-course segment owing to the course inaccuracies. The increased laser-pulse density can be avoided by the course correction.

It is also particularly advantageous to use the
15 method according to the invention whenever a laser beam is used as the beam and a mirror with a galvanometer motor is used as the movable beam-directing device. Indeed, for mirrors with a galvanometer motor, the problem the beam-directing device's mechanical inertia has to date been very
20 noticeable.

The method according to the invention can be used particularly advantageously for processing or modifying a surface, in particular for writing dial plates, or for applying or removing material, for example during laser
25 structuring or doping of semiconductor surfaces by means of ion beams.

If an ion beam is used as the beam, then it is particularly advantageous to use a magnetic lens as the beam-directing device.

30 The invention will be explained in more detail below with reference to exemplary embodiments and the associated figures.

Figures 3a to 3c show a predetermined desired course, a desired course corrected according to the invention and the actual course resulting therefrom.

Figure 4 shows a desired course with continuous direction changing, which has been approximated by a desired course with discrete direction changes.

Figure 3a shows a predetermined desired course 1, in which a direction change from a first to a second direction takes place. The desired course 1 is described with the course velocity v_B , in each case in the arrow direction.

Figure 3b shows the corrected desired course 2 corresponding to Figure 3a. At the turning point of the desired course, a first straight-line section of length L , which points in the first direction, is added. This straight-line section is described with the course velocity v_B . A second straight-line section, which has the same length and points in the opposite direction, is added to the first straight-line section. This second straight-line section is described with the maximum course velocity v_{max} , so that it virtually represents a return instruction to the point of the direction change. After the bend, following the second direction, the corrected desired course corresponds to the desired course, which is described with the course velocity v_B .

Figure 3c shows the achieved actual course 5 corresponding to Figure 3b. The two straight-line segments are described with the course velocity v_B in the direction given by the arrows. Apart from a small gap and a slight curvature of the second direction section at the point of the direction change, the corrected actual course 5 corresponds to the predetermined desired course.

Figure 4 shows a curved desired course 6. It is approximated by a desired course 1 with successive discrete direction

changes. The points of the direction changes are indicated by arrows. This desired course 1 with discrete direction changes may then itself be corrected by using with the method according to the invention.

- 5 The invention is not limited to the embodiments represented by way of example, but rather is defined in its most general form by claim 1.

Patent Claims

1. A method for describing a course, according to a predetermined desired course (1) having a direction change, with a beam of particles or waves,

5 wherein a movable beam-directing device influences the direction of the beam, so that the latter describes, when projected onto a surface, an actual course (3, 4) with a velocity v_B ,

10 wherein the desired course (1) is converted by a drive device into a corrected desired course (2) which, in the vicinity of the discrete direction change from a first direction to a second direction, describes a diversion which is obtained by appending and/or deleting arbitrary sections to/from the desired course (1), and wherein the
15 corrected desired course (2) is translated by the drive device into control instructions for the beam-directing device.

2. The method as claimed in claim 1, in which the sections are straight-line sections.

20 3. The method as claimed in claim 1 or 2,
- wherein the actual course (3, 4) is described with a constant course velocity v_B ,
- wherein, in the case of a straight-line desired course (1), the actual course (3, 4) is described with a constant
25 delay by the response error time t_s owing to the mechanical inertia of the beam-directing device,
- wherein the corrected desired course (2) is obtained from the desired course (1)

- by adding a first straight-line section of length L ,
30 which points in the first direction and for which: $L = v_B \times t_s$, to the previous course at the point of the direction change,

- by adding a second straight-line section of length L , which points in the opposite direction and for which a
35 maximum course velocity v_{max} is specified, where $v_{max} > v_B$, to the previous course at the far end of the first straight-line section from the point of the direction change.

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4. The method as claimed in claims 1 to 3, in which a desired course (6) with a continuous direction change is approximated by a desired course (1) with successive discrete direction changes.

5 5. The method as claimed in claims 1 to 4, in which a pulsed beam is used.



6. The method as claimed in claims 1 to 5, in which a laser beam is used as the beam and a mirror with a galvanometer motor is used as the movable beam-directing device.

10 7. Use of the method as claimed in claims 1 to 6 for processing or modifying a surface or for applying or removing material.

8. Use of the method as claimed in claims 1 to 6 for writing guard plates or dial plates.

15 9. The method as claimed in claims 1 to 5, in which an ion beam is used as the beam and a magnetic lens is used as the beam-directing device.