

Description

Title of Invention: PROCESSING SYSTEM FOR PROCESSING AN OBJECT

Technical Field

[0001] The present disclosure relates to a processing system for processing an object, such as an aircraft, by irradiating the object with irradiation light and to a method for modifying a surface of an object using such processing system.

Background

[0002] US 2017/0144255 A1 discloses, as a processing system that is configured to process an object, a processing system that forms a structure by irradiating a surface of an object with processing light. This type of processing system is required to allow more accuracy and flexibility.

Summary

[0003] According to a first aspect, a processing system for processing an object by irradiating the object with irradiation light may comprise a supporting apparatus. The processing system may comprise an irradiation unit. The irradiation unit may be movably supported by the supporting apparatus. The irradiation unit may be configured to irradiate the object with the irradiation light. The supporting apparatus may comprise at least a first base member. The supporting apparatus may comprise at least a second base member. At least one of the first and second base members may be movable with respect to the other one of the first and second base members. The supporting apparatus may comprise a carrier member. The carrier member may be held by the first base member. The carrier member may be held by the second base member. The carrier member may have a first end and a second end. The supporting apparatus may comprise a holding unit. The holding unit may be configured to hold the irradiation unit. The supporting apparatus may be convertible at least between a first configuration and a second configuration. In the first configuration, the holding unit may be positionable at the carrier member between the first base member and the second base member so that one of the first and second base members is positioned closer to one of the first and second ends than the holding unit and the other one of the first and second base members is positioned closer to the other one of the first and second ends than the holding unit. In the second configuration, at least one of the first end and the second end of the carrier member may protrude from the respective one of the first and second base members. In the second configuration, the holding unit may be positionable at the carrier member so that one of the first and second base members is positioned between the other one of the first and second base members and the

holding unit.

- [0004] According to a second aspect, there is provided a method for modifying a surface of an object. The method may comprise providing the processing system according to the present disclosure. The method may comprise positioning the processing system relative to the surface. The method may comprise modifying the surface by irradiating the surface with the irradiation light to form a surface structure.

Brief Description of Drawings

- [0005] [Fig.1]Fig. 1(a) is a perspective view of a processing system according to the present disclosure, wherein the supporting apparatus is in the second configuration. Fig. 1(b) is a perspective view of the processing system of Fig. 1(a), wherein the supporting apparatus is in the first configuration.
- [Fig.2]Fig. 2 is a perspective view of the processing system of Fig. 1(a), wherein the supporting apparatus is in an alternative second configuration.
- [Fig.3]Fig. 3(a) is a perspective view of the processing system of Fig. 2, wherein the supporting apparatus has a connection structure. Fig. 3(b) is a perspective view of the processing system of Fig. 1(b), wherein the supporting apparatus has a connection structure.
- [Fig.4]Fig. 4(a) is a perspective view of the processing system of Fig. 2, processing a wing of an aircraft. Fig. 4(b) is a perspective view of the processing system of Fig. 4(a) with a different configuration of the carrier member.
- [Fig.5]Fig. 5(a) is a perspective view of the processing system of Fig. 1(b), processing a wing of an aircraft. Fig. 5(b) is a perspective view of the processing system of Fig. 5(a) with a different configuration of the carrier member.
- [Fig.6]Fig. 6(a) is a side view of a processing system of the present disclosure, processing a wing of an aircraft in the first configuration. Fig. 6(b) is a side view of the processing system of Fig. 6(a) in the second configuration.
- [Fig.7]Fig. 7 is a side view of parts of a processing system according to the present disclosure.
- [Fig.8]Fig. 8 is an enlarged perspective view of a part of Fig. 7.
- [Fig.9]Fig. 9 is a perspective view of an irradiation light enclosure structure of a processing system according to the present disclosure.
- [Fig.10]Fig. 10(a) is a perspective view of the rigid structure of the irradiation light enclosure structure shown in Fig. 9 including a schematic perspective view of the textured structure. Fig. 10(b) is a cross-sectional view of the rigid structure of Fig. 10(a) including a schematic perspective view of the textured structure.
- [Fig.11]Fig. 11 is a schematic side view of parts of a processing system according to the present disclosure.

[Fig.12]Fig. 12 is a schematic side view of base members of a processing system according to the present disclosure.

[Fig.13]Fig. 13 is a schematic side view of parts of a processing system according to the present disclosure.

[Fig.14]Fig. 14 is a schematic illustration of a vibration reduction means of a processing system according to the present disclosure.

[Fig.15]Fig. 15 is a schematic illustration of a vibration reduction means of a processing system according to the present disclosure.

[Fig.16]Fig. 16 is a schematic illustration of a tracking system and a rotation mount of a processing system according to the present disclosure.

[Fig.17]Fig. 17 shows further examples of objects that can be processed by a processing system according to the present disclosure.

DETAILED DESCRIPTION OF PARTICULAR EMBODIMENTS

[0006] For a fuller understanding of the effects and advantages of the present disclosure, and to show how the same may be carried into effect, embodiments according to the disclosure will be described in detail with reference to the accompanying drawings. The embodiments hereinafter described should be understood not to the limit the scope of application or implementation of the present disclosure, or the principles by which it attains its effects or advantages in one or more embodiments. Accordingly, where elements of certain embodiments may be combined, substituted or omitted without affecting one or more effects or advantages thereof, such embodiments are also considered to form part of the disclosure as would readily be understood by one skilled in the art. Moreover, further certain individual features or modifications or substitutions thereof described in this context can be combined with other features of the described embodiments to form further embodiments of the disclosure.

[0007] Throughout the drawings, the same reference numerals are used for the same or similar elements.

[0008] Fig. 1(a) is a perspective view of one embodiment of a processing system 1 for processing an object 2 by irradiating the object with irradiation light according to the present disclosure. The processing system 1 comprises a supporting apparatus 10 and an irradiation unit 20 movably supported by the supporting apparatus 10 and configured to irradiate the object 2 with the irradiation light. The supporting apparatus 10 comprises a first base member 11 and a second base member 12. The first base member 11 and the second base member 12 have a beam structure comprising multiple beams. The beams may be made of metal. Alternatively, the beams may be made of another material. The first base member 11 comprises wheels 112 for moving over the floor on which the first base member 11 is placed. Likewise, the second base member 12 comprises wheels 122 for moving over the floor on which the second base member

12 is placed. Wheels 112 and 122 may be rotatably mounted at the first base member 11 and the second base member 12, respectively, so as to be rotatable around a first rotation axis that is parallel to the floor. In this way, the first base member 11 and the second base member 12 are movable with respect to each other.

- [0009] Instead of wheels 112 and 122, as shown in Fig. 11, which is a schematic side view of parts of a processing system 1 according to the present disclosure, the first base member 11 and the second base member 12 can be provided with chains 114, 124 for moving the first and second base members 11, 12 over a floor. Other means for permitting the first and second base member to be movable are also contemplated, including tracks, glide bearings, magnetic levitation units or air cushions.
- [0010] The first base member 11 and the second base member 12 extend in an extending direction that crosses, that is, intersects, a floor surface on which the first base member 11 and the second base member 12 are placed.
- [0011] The supporting apparatus 10 further comprises a carrier member 13 held by the first base member 11 and the second base member 12. The carrier member 13 has a first end 131 and a second end 132. The carrier member 13 has a crossbeam structure having a longitudinal axis that is parallel to a direction from the first end 131 to the second end 132 of the carrier member 13. The crossbeam structure of the carrier member 13 comprises multiple metal beams. The carrier member 13 is extended in a direction which crosses the extending direction of the first and second base members 11, 12.
- [0012] The supporting apparatus 10 further comprises a holding unit 14 that is configured to hold the irradiation unit 20. The holding unit 14 is attached to the carrier member 13 so as to be movable with respect to the carrier member 13 in a first direction. The first direction is parallel to the direction from the first end 131 to the second end 132 of the carrier member 13. Alternatively, the first direction may be oblique to the direction from the first end 131 the second end 132 of the carrier member 13. The carrier member 13 is movably held by the first and second base member 11, 12 so as to be movable along the second direction that crosses the first direction, and so as to be movable along the third direction that crosses the first and second directions. In the embodiment shown in Fig. 1(a), the first direction, the second direction, and the third direction are respectively perpendicular to each other. In this way, the irradiation unit 20 is movably supported by the supporting apparatus 10 so as to be movable in all three directions of space.
- [0013] Fig. 13 is a schematic side view of parts of a processing system according to the present disclosure. The supporting apparatus 10 further comprises a linear motor drive 101 for movement of the holding unit 14 in the first direction. The linear motor drive may use a magnetic force to move a magnetic slider unit along a track of permanent

magnets, as known in the art.

- [0014] The first base member 11 comprises a movable platform 111 and the second base member 12 comprises a movable platform 121 on which the carrier member 13 is disposed for moving the carrier member 13 along the third direction. Alternatively, as shown in Fig. 11, the first base member 11 has a telescopic configuration 113 and the second base member 12 has a telescopic configuration 123 for moving the carrier member 13 along the third direction. The telescopic configuration 113, 123 is configured by several members that are movable against each other.
- [0015] Fig. 12 is a schematic side view of base members of a processing system 1 according to the present disclosure, wherein the supporting apparatus 10 further comprises a third and a fourth base member 102, 103 with movable platforms 1021, 1031, respectively, as a substitution for the first and second base members 11, 12, wherein the third and fourth base members 102, 103 have, in the embodiment shown, a smaller height than the first and second base members 11, 12. With this configuration, the processing system can be provided as a modular processing system.
- [0016] The supporting apparatus 10 shown in Fig. 1(a) is in the second configuration. That is, the second end 132 of the carrier member 13 protrudes from the second base member 12 and the holding unit 14 is positioned at the carrier member 13 so that the second base member 12 is positioned between the first base member 11 and the holding unit 14. In the particular configuration shown in Fig. 1(a), the second configuration of the supporting apparatus 10 is such that the first base member 11 and the second base member 12 are in contact with each other and the holding unit 14 holding the irradiation unit 20 is located to the side of the first base member 11 and the second base member 12. The supporting apparatus 10 is in the cantilever configuration. In this configuration, the processing system 1 has a highly versatile configuration because the irradiation unit 20 is supported by the supporting apparatus 10 at a portion of the carrier member 13 that protrudes with its second end 132 from the second base member 12, whereby the irradiation unit 20 can be freely brought to the desired position for processing an object 2 by irradiating the object 2 with irradiation light.
- [0017] Fig. 1(b) is a perspective view of the processing system 1 of Fig. 1(a). The elements of the processing system 1 shown in Fig. 1(b) are the same as those shown in Fig. 1(a) and a description thereof is omitted.
- [0018] The supporting apparatus 10 shown in Fig. 1(b) is in the first configuration. That is, the holding unit 14 is positioned at the carrier member 13 between the first base member 11 and the second base member 12 so that the first base member 11 is positioned closer to the first end 131 than the holding unit 14, and the second base member 12 is positioned closer to the second end 132 than the holding unit 14. In the particular configuration shown in Fig. 1(b), the first configuration of the supporting

apparatus 10 is such that the first end 131 is arranged at the first base member 11 and the second end 132 is arranged at the second base member 12. The supporting apparatus 10 is in the gantry configuration. In this configuration, the processing system 1 has a highly stable configuration because the irradiation unit 20 is supported by the supporting apparatus 10 at a portion of the carrier member 13 that is located between the first base member and 11 and the second base member 12. Accordingly, the portion of the carrier member 13 at that the irradiation unit 20 is positioned is less prone to vibration, thereby allowing for a processing of the object 2 by irradiating the object with irradiation light with an improved accuracy.

- [0019] The processing system according to the present disclosure may be for forming a riblet structure at the surface of an object, such as an aircraft. It has been found that a riblet structure at the surface of an aircraft reduces drag. In general, when an object moves relative to a medium, for example, a fluid, such as air, due to friction between the medium and the surface of the object drag acts on the object, opposite to the relative movement of the object. Drag decelerates the moving object, thereby decreasing the velocity of the object. Examples for objects where drag occurs include aircrafts, helicopters and helicopter blades, ships, land vehicles, turbine blades, and pipelines. In case of pipelines, drag on a medium flowing in a pipeline decreases the flow velocity of the medium relative to the pipeline.
- [0020] In case of an aircraft as an example of an object moving relative to air, drag acts on the aircraft, opposite to the relative movement of the aircraft. Therefore, drag decelerates the movement of the aircraft. This may lead to a higher fuel consumption when the aircraft is flying. Fuel consumption is one of the biggest cost factors for airlines. In addition, an increased fuel consumption may lead to increased carbon dioxide emissions. For at least these reasons, it is desirable to reduce drag.
- [0021] A riblet structure has originally been found on the skin of sharks. A riblet structure is a surface geometry with fine ribs that extend substantially in parallel with each other. Riblet structures as applied, for example, to aircraft desirably may exhibit riblets having a sharp tip, may have a height of some tens of micrometers, for example, at least ten micrometers, and may have a distance between adjacent riblets in the order of some tens of micrometers up to some hundreds of micrometers, for example ten micrometers to 500 micrometers.
- [0022] In order to form a riblet structure on, for example, a part of an aircraft, for example, it is possible to prepare a foil that comprises a riblet structure and to glue the foil directly on the surface of the part. However, such foils may increase the weight of the part, which may in the case of an aircraft increase fuel consumption. Another approach to form a riblet structure at the surface of the part is to process the aircraft by irradiating the part with laser light. More specifically, riblets may be formed into a surface or

surface layer such as dry paint on the part by irradiating the surface with the laser light beam and moving the laser beam over the surface, thereby taking away material by evaporation or ablation of the paint. In other words, the surface of the part is modified by irradiating the surface with laser light to form the riblet structure. By this processing technique, fine lateral grooves are formed in the surface of the part between which the riblets remain.

- [0023] Instead of using only one laser beam to produce the riblets at the surface of a part, it is also possible to use the principle of laser interference patterning to form the riblets more quickly in the surface of the part. Using an optical system, a laser beam may be split into plural beams (typically, two, three, or four) which may be combined at the surface of the aircraft in a region of overlap to form an interference pattern of alternating regions of relatively high and low intensity on the surface of the part. The region in which the interference pattern is formed may be moved over the surface of the aircraft optically or mechanically. With this technique, it is possible to form the riblet structure more quickly by forming multiple parallel grooves in the surface of the part at the same time.
- [0024] Riblet structures formed in the surface of a part by means of laser light can be formed by using a processing system. Such systems may include an irradiation unit. The irradiation unit may be configured to irradiate the surface of a part with the laser light. The irradiation unit may be a laser processing head. The laser processing head may be supported by a supporting apparatus. The supporting apparatus may be configured to support the irradiation unit in close proximity with the surface of the aircraft. The supporting apparatus may be configured to move the irradiation unit over the surface of the part. Here, and throughout the present disclosure, the supporting apparatus may also be referred to as a manipulator.
- [0025] In order for the riblet structure to have its desired effect of reducing drag, the riblet structure is desirably formed in the surface of the part, for example, in a layer of coating such as paint, in an accurate manner. Since a structure such as an aircraft is usually not painted until it is fully assembled, there may be a need to form a riblet structure in the surface of the fully assembled structure. This may give rise to a number of technical difficulties.
- [0026] Firstly, forming a riblet structure in a surface of an object as large as an aircraft or other large structure may be more difficult than processing smaller objects in terms of accuracy. This is because a relatively large-sized processing system for processing the structure by irradiating it with laser light may be required in order to ensure that all parts of the structure can be reached. Large-sized processing systems may, however, be more prone to vibration. Such vibration may make it difficult to form the riblets with high accuracy. Secondly, when the structure is already fully assembled, it may be more

difficult to reach each portion of the different parts of the structure, such as, in the case of an aircraft, the wings and the fuselage, with the processing system to form the riblets thereon, as compared to a case in which the parts of the structure are treated separately. This particularly applies to large-sized processing systems that do not have a versatile design allowing the system to be easily moved with respect to the structure.

[0027] Existing processing systems may use robotic arms, at the end of which an irradiation unit may be attached. However, such systems may generally be more prone to vibration, especially when the robotic arm is relatively long. Moreover, existing processing systems may use a scissor stage, on which a robotic arm may be placed. In some circumstances this may make it difficult to process an upper side of a part of a structure such as an aircraft wing as the scissor stage is typically required not to come into contact with the part. This may be particularly problematic for portions on a wing where the turbines, which may protrude from the wing, are located.

[0028] With the processing system according to the first aspect of the present disclosure, i.e., a processing system 1 for processing an object 2 by irradiating the object 2 with irradiation light, the processing system 1 comprising: a supporting apparatus 10, and an irradiation unit 20 movably supported by the supporting apparatus 10 and configured to irradiate the object 2 with the irradiation light, the supporting apparatus (10) comprising: at least a first base member 11 and a second base member 12, at least one of the first and second base members 11, 12 being movable with respect to the other one of the first and second base members 11, 12, a carrier member 13 held by the first base member 11 and the second base member 12 and having a first end 131 and a second end 132, and a holding unit 14 configured to hold the irradiation unit 20, wherein the supporting apparatus 10 is convertible at least between a first configuration and a second configuration, wherein in the first configuration, the holding unit 14 is positionable at the carrier member 13 between the first base member 11 and the second base member 12 so that one of the first and second base members 11, 12 is positioned closer to one of the first and second ends 131, 132 than the holding unit 14 and the other one of the first and second base members 11, 12 is positioned closer to the other one of the first and second ends 131, 132 than the holding unit 14, in the second configuration, at least one of the first end 131 and the second end 132 of the carrier member 13 protrudes from the respective one of the first and second base members 11, 12, and the holding unit 14 is positionable at the carrier member 13 so that one of the first and second base members 11, 12 is positioned between the other one of the first and second base members 11, 12 and the holding unit 14, the holding unit 14 holding the irradiation unit 20 may, in the first configuration of the supporting apparatus 10, be positioned at the carrier member 13 between the first base member 11 and the second base member 12. In this configuration, the supporting apparatus 10

supporting the irradiation unit 20 may have a gantry-type configuration. Since the holding unit 14 and the irradiation unit 20 may be positioned at the carrier member 13 between the first base member 11 and the second base member 12, the irradiation unit 20 may be supported by the supporting apparatus 10 in a more stable manner as opposed to a situation in which the irradiation unit 20 is mounted at the end of a robotic arm. Therefore, the object 2 can be irradiated by the irradiation unit 20 with an improved accuracy.

[0029] For example, in case of processing an aircraft by irradiating the aircraft with laser light in order to form a riblet structure in the aircraft paint, the riblet structure may be most effective at the wings of the aircraft in terms of reducing drag. Hence, it may be of particularly importance for the processing system 1 to process the wings of an aircraft with high accuracy. With the processing system 1 comprising the supporting apparatus 10 according to the present disclosure, it may be possible, in the first configuration of the supporting apparatus 10, to place the first base member 11 on one side of the wing and the second base member 12 on the other side of the wing, and to position the irradiation unit 20 between the first base member 11 and the second base member 12 so that the irradiation unit 20 is located above or below the wing of the aircraft. Since the irradiation unit 20 may be supported by both the first base member 11 and the second base member 12 between the first base member 11 and the second base member 12, it may be more stably supported so that the riblet structure can be formed with an improved accuracy at the wing.

[0030] On the other hand, the supporting apparatus 10 of the processing system 1 according to the present disclosure may be converted to a second configuration, in which at least one of the first end 131 and the second end 132 of the carrier member 13 may protrudes from the respective one of the first and second base members 11, 12 and the holding unit 14 holding the irradiation unit 20 may be positionable at the carrier member 13 so that one of the first and second base members 11, 12 is positioned between the other one of the first and second base members 11, 12 and the holding unit 14. In other words, the holding unit 14 holding the irradiation unit 20 can be positioned to the side of both base members. In particular, the irradiation unit 20 can be positioned to the side of both base members and at a portion of the carrier member 13 close to the end of the carrier member 13 protruding from the respective one of the first and second base members 11, 12. In this configuration, the supporting apparatus 10 supporting the irradiation unit 20 may adopt a cantilever-type configuration. Since the irradiation unit 20 may be positioned to the side of both base members, the irradiation unit 20 may be freely supported and can more easily reach portions of the object 2 that may not be easily reachable when the supporting apparatus 10 adopts the first configuration, in which the irradiation unit 20 may be located between the first and second

base members 11, 12. Thus, the processing system 1 comprising the supporting apparatus 10 according to the present disclosure may be regarded as having a versatile design.

[0031] For example, in case of processing an aircraft by irradiating the aircraft with laser light in order to form a riblet structure in the aircraft paint, the riblet structure can be formed at portions pertaining to the fuselage 22 of the aircraft, such as the nose of the aircraft, with the supporting apparatus 10 adopting the second configuration. In this configuration, the supporting apparatus 10 may adopt a cantilever configuration and the irradiation unit 20 may be positioned to the side of both base members. With this configuration, the irradiation unit 20 can be brought in close proximity to the fuselage 22, for example the nose, of the aircraft more easily than in other cases in which the supporting apparatus 10 may adopt the first configuration. Thus, the processing system 1 comprising the supporting apparatus 10 according to the present disclosure can process the aircraft by irradiating it with laser light in a versatile way.

[0032] In the second configuration of the supporting apparatus 10, in which the supporting apparatus 10 may adopt a cantilever configuration, the flexibility of the system may be increased but the irradiation unit 20 may be supported less stably as opposed to the first configuration of the supporting apparatus 10, in which the supporting apparatus 10 adopts a gantry configuration. This is because, instead of being positioned between the first base member 11 and the second base member 12 as in the first configuration, the irradiation unit 20 may be positioned to the side of the first base member 11 and the second base member 12 in the second configuration, in which position it may be more prone to vibration. However, it is to be noted that a riblet structure can still be satisfactorily formed using the processing system 1 in the second configuration. That is, the riblet structure at the fuselage 22, which can be easily formed using the processing system 1 with the supporting apparatus 10 in the second configuration, may contribute less in terms of drag reduction than the riblet structure at the wings. Therefore, the accuracy with which the riblet structure is formed at the fuselage 22 may not need to be as high as the accuracy with which the riblet structure is formed at the wings. As a result, the processing system 1 comprising the supporting apparatus 10 according to the present disclosure may be regarded as being versatile and while still having the ability to process the object 2 with an improved accuracy.

[0033] The irradiation unit 20 may be configured to irradiate the object 2 with the irradiation light. For this purpose, the irradiation unit 20 may comprise an irradiation light source, such as a laser light source. On the other hand, an irradiation light source may be disposed separately from the irradiation unit 20, for example spaced apart from the irradiation unit 20, so that the irradiation unit 20 is configured to irradiate the object 2 with the irradiation light by conveying the irradiation light from the irradiation light

source to the object 2.

- [0034] The irradiation unit 20 may comprise an optical component system, the optical component system comprising at least one optical component, for irradiating the object 2 with irradiation light. As an example of optical components, a mirror, a lens, a beam splitter etc. are conceivable. In particular, an optical component system comprised in the irradiation unit 20 may be configured to focus the irradiation light onto a surface of the object 2. The irradiation unit 20 may be configured to produce a laser interference patterning. The irradiation unit 20 may be, for example, an interferometric processing head disclosed in US Patent Publication Nos. 2022/0258280, 2020/0139488 and 2022/0152741.
- [0035] The irradiation unit 20 may be movably supported by the supporting apparatus 10. The irradiation unit 20 may be suspended from the supporting apparatus 10 and/or disposed or placed on the supporting apparatus 10. "Movably supported" may mean that the irradiation unit 20 is supported by the supporting apparatus 10 in a way that it can move relative to the supporting apparatus 10. For example, this may be realized by the configuration of the holding unit 14, described in more detail below. By movably supporting the irradiation unit 20, different portions of the object 2 to be processed can be irradiated by the processing system 1. For example, with this configuration, the irradiation unit 20 can scan the surface of the object 2 to be processed.
- [0036] The supporting apparatus 10 according to the present disclosure may comprise the first base member 11 and the second base member 12, the carrier member 13, and the holding unit 14. Each of the first base member 11 and the second base member 12 may comprise a structure that has sufficient structural strength and integrity to at least support the carrier member 13, the holding unit 14, and the irradiation unit 20. For example, each of the first base member 11 and the second base member 12 may comprise a beam structure made of metal, such as steel or aluminum. Each of the first base member 11 and the second base member 12 may include a pedestal. The pedestal may be provided with weights so as to provide an increased stability of the first and second base members 11, 12 against falling.
- [0037] In general, each of the first base member 11 and the second base member 12 may have a size, in particular, a height, adapted to the size of the object 2 to be processed by the processing system 1. For example, in case of the object 2 being an aircraft, each of the first base member 11 and the second base member 12 may have a height of several meters and may occupy a surface area of several square meters on a floor on which the first base member 11 and the second base member 12 are placed. As one example, the first base member 11 and/or the second base member 12 may have a height of at least five meters or at least ten meters. As one example, the first base member 11 and/or the second base member 12 may occupy a surface area of a floor of

at least four square meters or at least six square meters.

- [0038] At least one of the first base member 11 and the second base member 12 may be movable with respect to the other one of the first base member 11 and the second base member 12 by being manually moveable, for example, by one or more persons, and/or by being moveable, for example, automatically movable, by a motor integrated in the first base member 11 and/or the second base member 12.
- [0039] It is also possible that the first base member 11 and the second base member 12 are connected to each other by a mechanical connection structure 19, for example, at a bottom portion of the first base member 11 and the second base member 12, the bottom portion being a portion close to the floor on which the first base member 11 and the second base member 12 are placed. Such a connection structure 19 may be removable and adjustable, for example, adjustable to a distance between the first base member 11 and the second base member 12. Such a connection structure 19 may improve overall stability of the supporting apparatus 10 and, thus, of the processing system 1.
- [0040] The carrier member 13 may have a crossbeam structure with a first end 131 and a second end 132. The crossbeam structure may be made of metal, such as steel or aluminum. For example, the carrier member 13 may have a rectangular or square-shaped cross-section in a direction from the first end 131 to the second end 132 of the carrier member 13. The carrier member 13 may be chosen so that it has a size adapted to the size of the object 2 to be processed. For example, in case of an aircraft as the object 2 to be processed, the carrier member 13 may have a length longer than the width of the wing of an aircraft, so that the wing can be positioned between the first base member 11 and the second base member 12. Since the turbines of an aircraft are attached to the wings and protrude from the wings to the front, the length of the carrier member 13 may be chosen so that it is longer than a distance from the rear side of the wing to the front side of the turbine 21. For example, the carrier member 13 may have a length of several meters. In one example, the carrier member 13 may have a length of at least five meters.
- [0041] The carrier member 13 may be held by the first base member 11 and the second base member 12 by suspending the carrier member 13 from the first base member 11 and the second base member 12, or by being disposed or placed on the first base member 11 and the second base member 12 so that the carrier member 13 rests on the first base member 11 and the second base member 12. The carrier member 13 may be held by the first base member 11 and the second base member 12 at an upper portion of the first base member 11 and the second base member 12 as seen in a direction perpendicular to a floor on which the first base member 11 and the second base member 12 are placed.
- [0042] The holding unit 14 may be a structure configured to be mounted on the carrier

member 13 and configured to hold the irradiation unit 20. The holding unit 14 may be mounted, for example, detachably mounted, on the carrier member 13 so as to be movable with respect to the carrier member 13, to thereby movably support the irradiation unit 20 at the supporting apparatus 10. For example, the holding unit 14 or the carrier member 13 may comprise wheels with which the holding unit 14 can roll along the carrier member 13 and/or or the holding unit 14 may be movably mounted to the carrier member 13 using a rail structure.

[0043] The holding unit 14 may be positionable at a side surface of the carrier member 13 or at a lower or upper side of the carrier member 13, as seen in a direction perpendicular to the floor on which the first base member 11 and the second base member 12 are placed.

[0044] In the first configuration of the supporting apparatus 10, the holding unit 14 is positionable at the carrier member 13 between the first base member 11 and the second base member 12 so that one of the first and second base members 11, 12 is positioned closer to one of the first and second ends than the holding unit 14 and the other one of the first and second base members 11, 12 is positioned closer to the other one of the first and second ends than the holding unit 14. Accordingly, the first configuration may also include a configuration in which the first base member 11 is arranged at the first end 131 of the carrier member 13 and the second base member 12 is arranged at the second end 132 of the carrier member 13, and the holding unit 14 is positioned at the carrier member 13 between the first base member 11 and the second base member 12. In such a configuration, the holding unit 14 and, thus, the irradiation unit 20 can move with respect to the carrier member 13 along the complete length of the carrier member 13. The first configuration may also include a configuration in which the first end 131 of the carrier member 13 protrudes from one of the first and second base members 11, 12 and the second end 132 of the carrier member 13 protrudes from the other one of the first and second base members 11, 12, and the holding unit 14 is positioned at the carrier member 13 between the first base member 11 and the second base member 12. In this configuration, the irradiation unit 20 can be more stably held by the supporting apparatus 10 because the distance between the first base member 11 and the second base member 12 is smaller. Accordingly, the portion of the carrier member 13 between the first base member 11 and the second base member 12 may be less prone to vibration.

[0045] In the second configuration of the supporting apparatus 10, at least one of the first end 131 and the second end 132 of the carrier member 13 may protrude from the respective one of the first and second base members 11, 12 and the holding unit 14 may be positioned at the carrier member 13 so that one of the first and second base members 11, 12 is positioned between the other one of the first and second base

members 11, 12 and the holding unit 14. The second configuration may include a configuration in which one of the first end 131 and the second end 132 of the carrier member 13 protrudes from the respective one of the first and second base members 11, 12 and the other one of the first end 131 and the second end 132 of the carrier member 13 is arranged at the other one of the first and second base members 11, 12. For example, the second configuration may include a configuration in which the first and second base members 11, 12 are arranged in close proximity to each other, or are even in contact with each other, and are arranged at one of the first end 131 and the second end 132 of the carrier member 13, and the holding unit 14 is positionable at a portion of the carrier member 13 close to the other one of the first end 131 and the second end 132 of the carrier member 13. In general, in the second configuration, the longer the distance between the first base member 11 and the second base member 12, the shorter the distance of the portion of the carrier member 13 protruding from the respective one of the first and second base members 11, 12. Accordingly, the more stable the holding unit 14 can be held. Furthermore, the second configuration may include a configuration in which both the first end 131 and the second end 132 of the carrier member 13 protrude from the respective one of the first and second base members 11, 12. In any event, the holding unit 14 and, thus, the irradiation unit 20 is positionable to the side of the first and second base members 11, 12, so that the first and second base members 11, 12 are positioned on the same side of the holding unit 14 and, thus, the irradiation unit 20.

[0046] In order to convert the supporting apparatus 10 from the first configuration to the second configuration or from the second configuration to the first configuration, the holding unit 14 may be detached from the carrier member 13 and attached to another portion of the carrier member 13. For example, when the supporting apparatus 10 is in the first configuration, the holding unit 14 is positioned at the carrier member 13 between the first base member 11 and the second base member 12. In order to convert the supporting apparatus 10 from the first configuration to the second configuration, the holding unit 14 may be detached from the carrier member 13. Subsequently, the distance between the first base member 11 and the second base member 12 may be modified, for example, by moving one of the first base member 11 and the second base member 12 towards the other one of the first base member 11 and the second base member 12. Then, the holding unit 14 may be re-attached to the carrier member 13 at a portion of the carrier member 13 located to the side of the first and second base members 11, 12, so that the first and second base members 11, 12 are positioned on the same side of the holding unit 14.

[0047] The conversion between the first configuration and the second configuration of the supporting apparatus 10 may also be made automatically and/or motorized. For

example, the first and second base members 11, 12 may have a design allowing the holding unit 14 to move past, across, or through the first and second base members 11, 12 without having to detach the holding unit 14 from the carrier member 13.

- [0048] With this configuration, the supporting apparatus 10 and, thus, the processing system 1 can be converted quickly between the first configuration and a second configuration. A quick convertibility is desirable in terms of costs. For example, in case of an aircraft as the object 2 to be processed, due to the versatile structure of the wings of an aircraft, even low wind speeds or walking persons can cause the wings to vibrate. Therefore, processing the surface of the assembled aircraft usually requires an aircraft hangar which is expensive, and the longer the aircraft is on the ground the more costs are created.
- [0049] In case of an aircraft as the object 2 to be processed, even though the first configuration of the supporting apparatus 10 is particularly beneficial in terms of stably supporting the irradiation unit 20 at the wings of an aircraft, thereby achieving an improved accuracy of the formation of the riblet structure at the wings, the supporting apparatus 10 may as well be used in the second configuration for forming the riblet structure at the wings, for example, in case the overall stability of the supporting apparatus 10 allows for an accurate formation of the riblet structure.
- [0050] As mentioned above, both of the first and second base members 11, 12 may be movable with respect to each other.
- [0051] For example, each of the first base member 11 and the second base member 12 may be movable with respect to the other one of the first base member 11 and the second base member 12 by being manually moveable, for example, by one or more persons, and/or by being moveable, for example, automatically movable, by a motor integrated in the first base member 11 and/or the second base member 12.
- [0052] With the configuration according to which both of the first and second base members 11, 12 may be movable with respect to each other, the supporting apparatus 10 and, thus, the processing system 1 is even more versatile.
- [0053] As mentioned above, the first and second base members 11, 12 may extend in an extending direction that crosses a floor surface on that the first and second base members 11, 12 are placeable.
- [0054] For example, each of the first base member 11 and the second base member 12 may have a tower-like structure and a longitudinal axis. The extending direction may be a direction parallel to the longitudinal axis of the first base member 11 and the second base member 12. The extending direction may cross the floor surface at an angle of substantially 90°, so that the first base member 11 and the second base member 12 are substantially perpendicular to the floor. However, the extending direction may also cross the floor at an oblique angle.

- [0055] In this context, whenever the term “substantially” is used together with an angle or a direction, the term “substantially” is to be understood as not only including the precise value of the angle or direction concerned, but also small variations around that value suitable to attain an equivalent result. For example, for two elements to be substantially parallel may in some embodiments require the elements to be parallel within 10 degrees, within 5 degrees, within 2 degrees or within 1 degree.
- [0056] The extending direction of the first base member 11 and the second base member 12 with respect to the floor surface may also be adjustable, either manually or automatically.
- [0057] With the configuration according to which the first and second base members 11, 12 may extend in an extending direction that crosses a floor surface on that the first and second base members 11, 12 are placeable, the supporting apparatus 10 and, thus, the processing system 1 is even more versatile.
- [0058] As mentioned above, the carrier member 13 may be extended in a direction which crosses the extending direction of the first and second base members 11, 12.
- [0059] For example, the carrier member 13 may have a crossbeam structure having a longitudinal axis parallel to the direction from the first end 131 to the second end 132 of the carrier member 13. In this case, the carrier member 13 may extend in a direction which crosses the extending direction of the first and second base members 11, 12, so that the longitudinal axis of the carrier member 13 crosses a longitudinal axis of the first base member 11 and the second base member 12 at an angle of substantially 90°. However, the carrier member 13 may also extend in a direction which crosses the extending direction of the first base member 11 and the second base member 12 at an oblique angle.
- [0060] As mentioned above, the holding unit 14 may be movably held by the carrier member 13 so as to be movable along a first direction, the first direction being parallel or oblique to a direction from the first end 131 to the second end 132 of the carrier member 13, and wherein the carrier member 13 may be movably held by the first and second base members 11, 12 so as to be movable along a second direction that crosses the first direction, and so as to be movable along a third direction that crosses the first and second directions.
- [0061] As mentioned above, the holding unit 14 or the carrier member 13 may comprise wheels with which the holding unit 14 can roll along the carrier member 13 and/or the holding unit 14 may be movably mounted to the carrier member 13 using a rail structure.
- [0062] In case the first direction is parallel to the direction from the first end 131 to the second end 132 of the carrier member 13, the holding unit 14 is movable in parallel to the direction of extension of the carrier member 13. For example, in case the carrier

member 13 has a longitudinal axis extending from the first end 131 to the second end 132 of the carrier member 13, the holding unit 14 is movable in parallel to the longitudinal axis.

- [0063] In case the first direction is oblique to the direction from the first end 131 of the second end 132 of the carrier member 13, the holding unit 14 is movable at a slight angle to the direction of extension of the carrier member 13. For example, such angle may be greater than 0° and up to and including 45° . Preferably, such angle may be greater than 0° and up to and including 30° .
- [0064] The second direction may be a direction that is substantially perpendicular to the first direction and substantially parallel to the floor surface on which the first base member 11 and the second base member 12 are placed. Movement of the carrier member 13 along the second direction may be realized by a spindle drive.
- [0065] The third direction that crosses the first and second directions may be a direction that is substantially perpendicular to the floor surface on which the first base member 11 and the second base member 12 are placed. In other words, the third direction may be an up-down direction. Movement of the carrier member 13 along the third direction may be realized by a spindle drive.
- [0066] With the configuration according to which the holding unit 14 may be movably held by the carrier member 13 so as to be movable along a first direction, the first direction being parallel or oblique to a direction from the first end 131 to the second end 132 of the carrier member 13, and wherein the carrier member 13 may be movably held by the first and second base members 11, 12 so as to be movable along a second direction that crosses the first direction, and so as to be movable along a third direction that crosses the first and second directions, the flexibility of the processing system 1 is further improved and simple mechanisms can be used for the movements. This is because, in addition to one of the first and second base members 11, 12 being movable with respect to the other one of the first and second base members 11, 12, the irradiation unit 20, which is held by the holding unit 14, the holding unit 14 being positionable at the carrier member 13, can be moved in three different directions that cross each other. For example, in case of an aircraft as the object 2 to be processed, for the formation of a parallel riblet structure in the aircraft paint using a laser interference patterning, the irradiation unit 20 may be or may comprise a laser processing head, held by the holding unit 14. In this case, when the holding unit 14 moves along the first direction, a lane consisting of parallel grooves in the aircraft paint between which the riblets are formed, may be formed in the aircraft paint. Since the carrier member 13 can be moved along the second direction that crosses the first direction and that may be a direction substantially parallel to the floor on which the first base member 11 and the second base member 12 are placed, a further lane of parallel grooves can be formed in the

aircraft paint next to the lane formed before, without the need to move the first base member 11 and/or the second base member 12. Two or more lanes of riblets arranged in parallel to each other form a patch. Hence, with this configuration, the object 2 can be processed more quickly.

- [0067] As mentioned above, the first and second base members 11, 12 may comprise a movable platform 111, 121 on which the carrier member 13 may be disposed for moving the carrier member 13 along the third direction and/or have a telescopic configuration 113, 123 for moving the carrier member 13 along the third direction.
- [0068] The movable platform 111, 121 may be a movable stage on which the carrier member 13 is disposed. It is also conceivable that the movable platform 111, 121 is realized by a movable cross bar, which is movable in the third direction within the first base member 11 and the second base member 12. In this case, the first base member 11 and the second base member 12 have a constant height, and the movable platform 111, 121 is movable along the height direction of the first base member 11 and the second base member 12. The movable platform 111, 121 may include the drive mechanism for movement of the carrier member 13 along the second direction.
- [0069] In case of a telescopic configuration 113, 123 of the first base member 11 and the second base member 12, the height of the first base member 11 and the second base member 12 is variable. The telescopic configuration 113, 123 may be provided in addition to the movable platform 111, 121 or as an alternative configuration to the movable platform 111, 121.
- [0070] As mentioned above, movement of the carrier member 13 along the third direction may be realized by a spindle drive.
- [0071] With the configuration according to which the first and second base members 11, 12 may comprise a movable platform 111, 121 on which the carrier member 13 may be disposed for moving the carrier member 13 along the third direction and/or have a telescopic configuration 113, 123 for moving the carrier member 13 along the third direction, a simple structure for moving the carrier member 13 in the third direction may be provided. In particular, a configuration involving the telescopic configuration 113, 123 further improves flexibility of the processing system 1.
- [0072] As mentioned above, the supporting apparatus 10 may further comprise a linear motor drive 101 for movement of the holding unit 14 in the first direction.
- [0073] The linear motor drive 101 may be included in the carrier member 13 and may be used for moving the holding unit 14 and, thus, the irradiation unit 20 along the carrier member 13 in the first direction, i.e., parallel or oblique to the direction from the first end 131 to the second end 132 of the carrier member 13.
- [0074] With the configuration according to which the supporting apparatus 10 may further comprise a linear motor drive 101 for movement of the holding unit 14 in the first

direction, the holding unit 14 can be moved in the first direction using a simple motor drive mechanism, which still allows a smooth and uniform movement.

- [0075] As mentioned above, each of the first base member 11 and the second base member 12 may be provided with wheels 112, 122 or chains 114, 124 for moving the first and second base members 11, 12 over a floor.
- [0076] The wheels 112, 122 or chains 114, 124 may be driven by a motor, which may be controlled via a remote controller by a user. Alternatively, the motor may be controlled via a control unit.
- [0077] With the configuration according to which each of the first base member 11 and the second base member 12 may be provided with wheels 112, 122 or chains 114, 124 for moving the first and second base members 11, 12 over a floor, the first base member 11 and the second base member 12 can be moved over a floor on which the first base member 11 and the second base member 12 are placed in a simple manner.
- [0078] Alternatively, each of the first base member 11 and the second base member 12 may be movable over a floor by means of a rail system on or in the floor, wherein each of the first base member 11 and the second base member 12 may be mounted on the rail system. For example, the carrier member 13 may be held in a fixed position by the first and second base members 11, 12 with respect to the second direction, so as not to be movably held by the first and second base members 11, 12 along the second direction. In this case, the first base member 11 and the second base member 12 may be movable over the floor by means of the rail system, so as to move, together with the carrier member 13, along the second direction. Alternatively, the first base member 11 and the second base member 12 may be movable over the floor by means of the wheels 112, 122 or chains 114, 124, so as to move, together with the carrier member 13, along the second direction.
- [0079] As mentioned above, the supporting apparatus 10 may further comprise a third and a fourth base member 103 as a substitution for the first and second base members 11, 12, wherein the third and fourth base members may have a different height than the first and second base members 11, 12.
- [0080] Except for the different height of the third and fourth base members, the third base member 102 and the fourth base member 103 may have the same configuration and the same features as the first base member 11 and the second base member 12. The third base member 102 and the fourth base member 103 may have the same height.
- [0081] With the configuration according to which the supporting apparatus 10 may further comprise a third and a fourth base member 103 as a substitution for the first and second base members 11, 12, wherein the third and fourth base members may have a different height than the first and second base members 11, 12, the processing system 1 can be provided as a modular processing system 1, because the third base member 102

and the fourth base member 103 are a substitution for the first base member 11 and the second base member 12. For example, the first base member 11 and the second base member 12 may have a height that is smaller than the height of the third base member 102 and the fourth base member 103. In case of an aircraft as the object 2 to be processed, the first base member 11 and the second base member 12 may be used in the supporting apparatus 10 for processing a lower side of the wing. In contrast, the third base member 102 and the fourth base member 103, which have a height that is greater than the height of the first base member 11 and the second base member 12, may be used in the supporting apparatus 10 for processing an upper side of the fuselage 22 of the aircraft. Hence, with this configuration, the flexibility of the processing system 1 is further improved.

[0082] Fig. 2 is a perspective view of the processing system 1 of Fig. 1(a), wherein the supporting apparatus 10 adopts an alternative second configuration. More specifically, the first base member 11 is arranged at the first end 131 but, in contrast to the configuration shown in Fig. 1(a), the second base member 12 is not in contact with the first base member 11, but is spaced apart from the first base member 11 in the first direction. Hence, the portion of the carrier member 13 at that the holding unit 14 and the irradiation unit 20 are arranged and that includes the second end 132 of the carrier member 13 protruding from the second base member 12 is shorter than the respective portion of the carrier member in the configuration shown in Fig. 1(a). As a result, since the protruding portion of the carrier member 13 is shorter, this portion is less prone to vibration. Thus, the cantilever configuration shown in Fig. 2 can achieve a more accurate processing as the cantilever configuration shown in Fig. 1(a). On the other hand, the configuration shown in Fig. 2 is less versatile than the configuration shown in Fig. 1(a).

[0083] Fig. 3(a) is a perspective view of the processing system 1 of Fig. 2, wherein the supporting apparatus 10 has a connection structure 19. The connection structure 19 in the present embodiment is a beam structure that connects the first base member 11 and the second base member 12 to each other. The beam structure may also be a metal beam structure. The connection structure 19 improves overall stability of the supporting apparatus 10 and, thus, of the processing system 1. The connection structure 19 shown in Fig. 3(a) comprises two parts arranged at respective sides of the first base member 11 and the second base member 12, as seen in the second direction. The connection structure 19 may be adjustable in length and detachably attachable to the supporting apparatus 10.

[0084] Fig. 3(b) is a perspective view of the processing system 1 of Fig. 1(b), wherein the supporting apparatus 10 has a connection structure 19. In this case, the connection structure 19 consists of a single part that is arranged between the first base member 11

and the second base member 12, at respective lower portions thereof, as seen in the third direction. With this configuration, in which the supporting apparatus 10 adopts the gantry configuration, sufficient space between the carrier member 13 and the connection structure 19 is provided in the third direction and in the first direction so that an object 2, such as a wing of an aircraft, can be properly processed by the processing system 1 shown in Fig. 3(b).

[0085] Figs. 4(a) and 4(b) are perspective views of the processing system 1 of Fig. 2, processing a wing of an aircraft as the object 2 to be processed. Both in Fig. 4(a) and in Fig. 4(b), the supporting apparatus 10 is used in the second configuration, i.e., in the cantilever configuration. In this configuration, the first base member 11 and the second base member 12 are positioned on the same side of the aircraft wing as the object 2 to be processed. While in Fig. 4(a), an upper side of an aircraft wing is processed by the irradiation unit 20, in Fig. 4(b), a lower side of the aircraft wing is processed by the irradiation unit. For that purpose, in the configuration shown in Fig. 4(a), the irradiation unit 20 is arranged at the lower side of the carrier member 13. On the other hand, in the configuration shown in Fig. 4(b), the irradiation unit 20 is arranged at the upper side of the carrier member 13. In the present embodiment, this is achieved by the carrier member 13 being rotatably held by the first and second base members 11, 12 so as to be rotatable around a rotation axis, wherein the rotation axis is parallel to the direction from the first end 131 to the second end 132 of the carrier member 13. More specifically, in order to convert the configuration shown in Fig. 4(a) to the configuration shown in Fig. 4(b), the carrier member 13 is rotated by 180° and, furthermore, the movable platform 111 of the first base member 11 and the movable platform 121 of the second base member 12 are lowered along the third direction.

[0086] As mentioned above, the carrier member 13 may rotatably held by the first and second base members 11, 12 so as to be rotatable around a rotation axis, the rotation axis being parallel to a direction from the first end 131 to the second end 132 of the carrier member 13.

[0087] For example, the carrier member 13 may be held by the first and second base members 11, 12 by means of a rotation mount 142 so as to be rotatable around a rotation axis.

[0088] With the configuration according to which the carrier member 13 may rotatably held by the first and second base members 11, 12 so as to be rotatable around a rotation axis, the rotation axis being parallel to a direction from the first end 131 to the second end 132 of the carrier member 13, the flexibility of the processing system 1 is further improved because it is also possible to adapt the position of the irradiation unit 20, which is held by the holding unit 14 at the carrier member 13, to a surface of the object 2 to be processed having a round contour. This may be particularly useful for

processing an object 2 such as a fuselage 22 of an aircraft.

- [0089] Instead of, or in addition to, the carrier member 13 being rotatable relative to the first and second base members 11, 12, the holding unit 14 and/or the irradiation unit 20 may be rotatable relative to the carrier member 13. For example, in this situation, the holding unit 14 and/or the irradiation unit 20 may be rotatable around an axis perpendicular to the rotation axis of the carrier member 13. This further may improve flexibility of the processing system 1. For example, in case the holding unit 14 and/or the irradiation unit 20 may be rotatable around an axis perpendicular to the rotation axis of the carrier member 13 and parallel, or substantially parallel, to the floor on which the first base member 11 and the second base member 12 are placed, downward irradiation and upward irradiation of the irradiation light from the irradiation unit 20 may be switched. In this case, carrier member 13 may be non-rotatable. An actuator for rotating the holding unit 14 and/or the irradiation unit 20 may be provided.
- [0090] The holding unit 14 may be configured to hold the irradiation unit 20 at opposite sides of the carrier member 13, the opposite sides being opposite in a direction perpendicular to a direction from the first end 131 to the second end 132 of the carrier member 13.
- [0091] For example, the holding unit 14 may be configured to be attachable to the carrier member 13 at a lower side or at an upper side of the carrier member 13, as seen in a direction perpendicular to the floor on which the first base member 11 and the second base member 12 are placed. For example, the holding unit 14 and, thus, the irradiation unit 20 may be manually, for example, by a user, remounted from the lower side of the carrier member 13 to the upper side of the carrier member 13. Furthermore, the holding unit 14 may be configured to be attachable to the carrier member 13 at a left side surface or at a right side surface of the carrier member 13, as seen in a direction parallel to the floor on which the first base member 11 and the second base member 12 are placed and perpendicular to a direction from the first end 131 to the second end 132 of the carrier member 13. This is, for example, the case for a carrier member 13 having a rectangular or square-shaped cross-section.
- [0092] Alternatively, the holding unit 14 may have a configuration with which the irradiation unit 20 can be attached to the holding unit 14 at opposite sides of the holding unit 14 with respect to the carrier member 13, such as, for example, at a lower side or at an upper side of the carrier member 13, as seen in a direction perpendicular to the floor on which the first base member 11 and the second base member 12 are placed. At this time, downward irradiation and upward irradiation of the irradiation light from the irradiation unit 20 may be switched. It may also be conceivable that the irradiation unit 20 comprises a first irradiation unit and a second irradiation unit. The first irradiation unit may be attached to a lower side of the carrier member 13 and the second ir-

radiation unit may be attached to an upper side of the carrier member 13, as seen in a direction perpendicular to the floor on which the first base member 11 and the second base member 12 are placed. At this time, the irradiation light from the second irradiation unit may be irradiated upward, and the irradiation light from the first irradiation unit 20 may be irradiated downward.

- [0093] With the configuration according to which the holding unit 14 may be configured to hold the irradiation unit 20 at opposite sides of the carrier member 13, the opposite sides being opposite in a direction perpendicular to a direction from the first end 131 to the second end 132 of the carrier member 13, the processing system 1 may have an improved flexibility as different sides of the object 2 to be processed can be processed without the need to completely rearrange the processing system 1 with respect to the object 2.
- [0094] As can be seen in Figs. 4(a) and Fig. 4(b), the first base member 11 and the second base member 12 are sized so that they can be arranged in a space between the aircraft fuselage 22 and the aircraft turbine 21. Moreover, the height in the third direction is chosen so that the irradiation unit 20 can process an upper side of the aircraft wing.
- [0095] Figs. 5(a) and 5(b) are perspective views of the processing system 1 of Fig. 1(b), processing a wing of an aircraft as the object 2 to be processed. The processing system 1 is the same as shown in Figs. 4(a) and 4(b), for which reason the description of the same elements and their configuration is omitted. However, as opposed to the configuration shown in Figs. 4(a) and 4(b), in Figs. 5(a) and 5(b), the supporting apparatus 10 is in the first configuration, i.e., in the gantry configuration. In this configuration, the aircraft wing as the object 2 processed is positioned between the first base member 11 and the second base member 12.
- [0096] While, in the first configuration, the stability of the processing system 1 is higher than in the second configuration, due to the irradiation unit 20 not being positioned at a protruding portion of the carrier member 13, thereby being less prone to vibration, the processing system 1 in the second configuration has a higher flexibility than in the first configuration. For example, it can easily be maneuvered around the aircraft turbine 21. In general, depending on the accuracy needed for the specific object to be processed, the supporting apparatus 10 can be used in the first configuration or in the second configuration. For example, in case of an aircraft as the object 2 to be processed, wherein a riblet structure is to be formed in the aircraft paint, in case the accuracy of the processing system 1 is sufficient, the supporting apparatus 10 can as well be used in the second configuration.
- [0097] As can be seen in Fig. 5(a), for example, the carrier member 13 can be moved in the second direction within the first base member 11 and the second base member 12, on the movable platform 111 and the movable platform 121. Thus, it is possible to form a

patch of a riblet structure, consisting of two or more parallel lanes of riblets, on the aircraft wing as wide as the carrier member 13 can be moved in the second direction within the first base member 11 and the second base member 12, without the need to move the first base member 11 and the second base member 12 with respect to the aircraft wing.

[0098] Fig. 6(a) is a side view of a processing system 1 of the present disclosure, processing a wing of an aircraft in the first configuration, and Fig. 6(b) is a side view of the processing system 1 of Fig. 6(a) in the second configuration. The configuration shown in Fig. 6(a) corresponds to the configuration shown in Fig. 5(b), and the configuration shown in Fig. 6(b) to correspond to the configuration shown in Fig. 4(b). As can be seen in Figs. 6(a) and 6(b), the carrier member 13 can be moved in the third direction within the first base member 11 and the second base member 12, so that the irradiation unit 20 held by the holding unit 14 at an upper side of the carrier member 13, as seen in the third direction, can move along the first direction below the aircraft wing as the object 2 to be processed.

[0099] Fig. 7 is a side view of parts of a processing system 1 according to the present disclosure. The supporting apparatus 10 is in the first configuration. The supporting apparatus 10 comprises a light input location 15, which is located at the first base member 11, and a light output location 16, which is located at the carrier member 13. Furthermore, the supporting apparatus 10 comprises a light conveying system 17 arranged to convey the irradiation light from the light input location 15 to the light output location 16. The light input location 15 is for receiving the irradiation light into the light conveying system 17 and the light output location 16 is for outputting the irradiation light from the light conveying system 17. As can be seen in Fig. 7, the holding unit 14 is configured to hold the irradiation unit 20 at a position for outputting the irradiation light from the light output location 16 into the irradiation unit 20. In the present embodiment, while the light input location 15 may be fixed at the first base member 11, the light output location 16 may be configured to move with the holding unit 14 along the first direction. Although not shown, the light conveying system 17 may comprise a number of optical components, such as mirrors, for guiding the irradiation light from the light input location 15 to the light output location 16. In the embodiment shown in Fig. 13, the supporting apparatus 10 further comprises an irradiation source 201 configured to produce the irradiation light, which is located at the first base member 11.

[0100] As mentioned above, the supporting apparatus 10 may further comprise a light input location 15 and a light output location 16, a light conveying system 17 arranged to convey the irradiation light from the light input location 15 to the light output location 16, the light input location 15 being for receiving the irradiation light into the light

conveying system 17 and the light output location 16 being for outputting the irradiation light from the light conveying system 17, wherein the holding unit 14 may be configured to hold the irradiation unit 20 at a position for outputting the irradiation light from the light output location 16 into the irradiation unit 20.

- [0101] The light conveying system 17 may be configured to guide the irradiation light. The light conveying system 17 may comprise at least one optical component, such as a lens, a mirror, a beam splitter, etc. to thereby convey the irradiation light from the light input location 15 to the light output location 16. The light conveying system 17 may be a closed system. For example, an irradiation light source may be provided at the first base member 11. In this case, the light input location 15 may also be provided at the first base member 11. The light output location 16, which is for outputting the irradiation light from the light conveying system 17, may be located at a position along the carrier member 13. At the light input location 15 and/or the light output location 16 further optical components, such as an array of mirrors, may be provided for receiving the irradiation light into the light conveying system 17 and, respectively, for outputting the irradiation light from the light conveying system 17. The irradiation light from the irradiation light source will then be received at a light input location 15 into the light conveying system 17. The light conveying system 17 may comprise suitable optical components for conveying the irradiation light from the light input location 15 at the first base member 11 to the light output location 16 at the carrier member 13. For example, these optical components need to be configured to convey the irradiation light around the corner between the first base member 11 and the carrier member 13.
- [0102] The light input location 15 may be for coupling in the irradiation light in the light conveying system 17. The light output location 16 may be for coupling out the irradiation light from the light conveying system 17. The light input location 15 and/or the light output location 16 may be variable so as to be adaptable to the configuration of the supporting apparatus 10 of the processing system 1.
- [0103] The light output location 16 may be movable together with the holding unit 14 along the carrier member 13 of the supporting apparatus 10. The light output location 16 may be included in the holding unit 14.
- [0104] The above concepts apply equivalently to a light input location 15 and a light output location 16 being located at different components of the supporting apparatus 10 than the first base member 11 and the carrier member 13.
- [0105] With the configuration according to which the supporting apparatus 10 may further comprise a light input location 15 and a light output location 16, a light conveying system 17 arranged to convey the irradiation light from the light input location 15 to the light output location 16, the light input location 15 being for receiving the irradiation light into the light conveying system 17 and the light output location 16 being

for outputting the irradiation light from the light conveying system 17, wherein the holding unit 14 may be configured to hold the irradiation unit 20 at a position for outputting the irradiation light from the light output location 16 into the irradiation unit 20, the supporting apparatus 10 can properly convey the irradiation light from an irradiation light source to the irradiation unit 20 and, hence, to the object 2 to be processed. The light conveying system 17 may include a steering optics to reduce positional variations in light output location 16 and/or to reduce angular variations in the illumination output from light output location 16. As such a steering optical system, for example, an optical system disclosed in US Pat. Nos. 5,731, 577 and 6,081,320 may be applied.

- [0106] As mentioned above, the supporting apparatus 10 may further comprise an irradiation source 201 configured to produce the irradiation light.
- [0107] The irradiation source 201 may be located at the first base member 11, at the second base member 12, at the carrier member 13, or at the holding unit 14 of the supporting apparatus 10. In case the processing system 1 comprises the light input location 15 and the light output location 16 and the light conveying system 17, the light input location 15 may be located close to the irradiation source 201, for example, at the same component of the supporting apparatus 10 as the irradiation source 201.
- [0108] The irradiation source 201 may be a laser light source. The laser light source may output pulsed light. The laser light source may produce near infrared light or infrared light. The laser light source may comprise, by way of example, a CO₂ laser.
- [0109] With the configuration according to which the supporting apparatus 10 may further comprise an irradiation source 201 configured to produce the irradiation light, the supporting apparatus 10 and, thus, the processing system 1 has a more compact configuration.
- [0110] However, in an alternative embodiment, the irradiation source 201 may also be provided separately from the supporting apparatus 10.
- [0111] Fig. 8 is an enlarged perspective view of a part of Fig. 7, including the second end 132 of the carrier member 13 and part of the second base member 12. The holding unit 14 is configured to hold the irradiation unit 20 at a side surface of the carrier member 13. At the opposite side of the carrier member 13, the holding unit 14 comprises an electronic component box 141, in which electronic components of the supporting apparatus 10 are accommodated. Accordingly, the weight of the irradiation unit 20 may be to some degree counterbalanced by the electronic component box 141 or vice versa.
- [0112] At the side surface of the carrier member 13, where the irradiation unit 20 is located, an irradiation light enclosure structure 18 is provided. The irradiation light enclosure structure 18 extends along the same direction as the carrier member 13, from the first

end 131 to the second end 132 of the carrier member 13. The irradiation light enclosure structure 18 encloses the irradiation light beam B.

[0113] As mentioned above, the supporting apparatus 10 may further comprise an irradiation light enclosure structure 18 for at least partly enclosing an irradiation light beam between the light input location 15 and the light output location 16.

[0114] The irradiation light enclosure structure 18 may be chosen so as to be non-transparent for the irradiation light. This is especially important in case of high-power laser light as the irradiation light.

[0115] In case the processing system 1 comprises the light input location 15 and the light output location 16 and the light conveying system 17, the irradiation light enclosure structure 18 may at least partly enclose the irradiation light beam between the light input location 15 and light output location 16. The irradiation light enclosure structure 18 may also at least partly enclose the light conveying system 17.

[0116] With the configuration according to which the supporting apparatus 10 may further comprise an irradiation light enclosure structure 18 for at least partly enclosing an irradiation light beam between the light input location 15 and the light output location 16, the irradiation light beam is protected from external influences, such as ambient air containing water vapor and/or dust particles. Moreover, with this configuration, persons are protected from the irradiation light beam. This is particularly important in case of laser light as the irradiation light. The irradiation light enclosure structure 18 may have a labyrinth seal structure.

[0117] Fig. 9 is a perspective view of the irradiation light enclosure structure 18 of the processing system 1 according to the present disclosure. The irradiation light enclosure structure 18 comprises a rigid structure 182 and a folding bellows 181 being at least partly surrounded by the rigid structure 182 (see Fig. 10(b)). The rigid structure 182 comprises differently oriented walls 1821 so as to have, in its cross-sectional profile, five corners. Also shown in Fig. 9 is the irradiation light beam B, which passes through the irradiation light enclosure structure 18. At the light output location 16, one or more mirrors is provided in order to couple out the irradiation light beam B from the irradiation light enclosure structure 18. Although not shown in Fig. 9, the irradiation light beam B coupled out from the irradiation light enclosure structure 18 is coupled in or received in the irradiation unit 20.

[0118] Fig. 10(a) is a perspective view of the rigid structure 182 of the irradiation light enclosure structure 18 shown in Fig. 9. As can be seen, the rigid structure 182 comprises six walls 1821 that are differently oriented so as to form a spiral or labyrinthine shape in the cross-sectional profile of the rigid structure 182. The rigid structure 182 may be made of sheet metal. Also shown is a schematic perspective view of the textured structure 1822 of the rigid structure 182. The textured structure 1822

comprises a surface pattern comprising a plurality of protrusions. The textured structure 1822 is formed on a surface facing the irradiation light beam B. The size of the protrusions is chosen so that the textured structure 1822 is configured to diffusely reflect the irradiation light. In an alternative configuration, the material of rigid structure 182, at least at the surface thereof, may have a microstructure which generates diffuse reflections, for example by including crystals, fibers, domains or other scattering centers at the surface. The microstructure of such a surface has a characteristic dimension such as grain size, domain size, fiber diameter which is similar to the wavelength of the laser light. Accordingly, the irradiation light is diffusely reflected.

[0119] As can be seen in Fig. 10(b), which is a cross-sectional view of the rigid structure 182 of Fig. 10(a) including a schematic perspective view of the textured structure 1822, in case the irradiation light beam B exits the folding bellows 181, which is surrounded by the rigid structure 182, for example, in case of damage of the folding bellows 181, the irradiation light beam B is incident on the walls 1821 of the rigid structure 182 and diffusely reflected by the textured structure 1822. Due to the diffuse reflection, the intensity of the irradiation light beam B is decreased upon reflection. Due to the provision of several differently oriented walls 1821 comprising the textured structure 1822, the irradiation light beam B is diffusely reflected multiple times before it exits the rigid structure 182 of the irradiation light enclosure structure 18. For example, in case the irradiation light is laser light having a high power, such as 500 W, when the laser light is diffusely reflected multiple times, the power is significantly reduced.

[0120] As mentioned above, the irradiation light enclosure structure 18 may comprise a folding bellows 181 and a rigid structure 182, the folding bellows 181 being at least partly surrounded by the rigid structure 182, wherein the rigid structure 182 may comprise differently oriented walls 1821 so as to have, in its cross-sectional profile, at least two, preferably at least three, corners. The rigid structure 182 may have a diffusing structure at a surface facing the bellows, the diffusing structure being configured to diffusely reflect the irradiation light.

[0121] The folding bellows 181 may generally have a tube-like structure having a longitudinal axis and include folds so that a length of the folding bellows 181 in the direction in which the folding bellows 181 is folded is adaptable. The folding bellows 181 may be made of metal, rubber, plastic, or leather.

[0122] The folding bellows 181 may be provided to enclose the irradiation light beam between the light input location 15 and the light output location 16. For example, in case the light input location 15 is located at the first base member 11 and light output location 16 is located at the carrier member 13 or the holding unit 14, the length of the

folding bellows 181 is adaptable upon movement of the carrier member 13 in the third direction and movement of the holding unit 14 in the first direction.

- [0123] The rigid structure 182 may be rigid as compared with the structure of the folding bellows 181. The rigid structure 182 may be made of metal, such as steel or aluminum. The rigid structure 182 may be made of sheet metal. The rigid structure 182 may be made of a polymer, such as polyether ether ketone (PEEK). The rigid structure 182 may be arranged at the carrier member 13 and extend in a direction from the first end 131 to the second end 132 of the carrier member 13. The rigid structure 182 may also be arranged at the first base member 11 and the second base member 12 and extend in an up-down direction. The rigid structure 182 may be adaptable in length, in the same direction as the folding bellows 181, for example, by having a telescopic configuration.
- [0124] The rigid structure 182 may have, in its cross-sectional profile, a labyrinth-like or spiral-like structure comprising differently oriented walls 1821 so as to have at least two, preferably at least three, more preferably at least four, and most preferably at least five corners. The differently oriented walls 1821 may include an angle with respect to each other at the corners of substantially 90°.
- [0125] The rigid structure 182 may be sized to allow optical components, such as mirrors, to be disposed therein, for example, for the irradiation light beam. Such optical components may be arranged at the light output location 16 of the supporting apparatus 10.
- [0126] The diffusing structure may be provided by a textured structure 1822 having a regular or irregular surface patterning including, for example, roughening, dimples or protrusions. The structure may have a convex or concave profile and may have a characteristic dimension similar to the wavelength of the laser light. The shape and/or size of the patterning is such that the irradiation light is diffusely reflect therefrom.
- [0127] The diffusing structure may be provided by the microstructure of the surface including, for example, crystals, fibres, domains or other scattering centres at the surface. The microstructure of the surface may have a characteristic dimension similar to the wavelength of the laser light. The shape and/or size of the microstructure is such that the irradiation light is diffusely reflect therefrom.
- [0128] With the configuration according to which the irradiation light enclosure structure 18 may comprise a folding bellows 181 and a rigid structure 182, the folding bellows 181 being at least partly surrounded by the rigid structure 182, wherein the rigid structure 182 may comprise differently oriented walls 1821 so as to have, in its cross-sectional profile, at least two, preferably at least three, corners. The rigid structure 182 may have a diffusing structure at a surface facing the bellows, the diffusing structure being configured to diffusely reflect the irradiation light, safety of the processing system 1 is increased because the irradiation light cannot easily escape from the irradiation light

enclosure structure 18. For example, in order for the irradiation light beam to be coupled out from the irradiation light enclosure structure 18, the irradiation light beam is scattered or reflected at the differently oriented walls 1821 of the rigid structure 182, thereby being diffusely reflected, which reduces the intensity of the irradiation light beam. This is particularly important in case a laser light beam is used as the irradiation light beam.

- [0129] In the embodiment shown in Fig. 13, the supporting apparatus 10 further comprises a purge gas means 104 configured to provide purge gas to the irradiation light enclosure structure 18 and the irradiation unit 20. The purge gas means in the embodiment shown in Fig. 13 has a pressurized purge gas container 1041, which is arranged at the second base member 12, and a purge gas line 1042, which leads from the purge gas container 1041 to the irradiation light enclosure structure 18 and the irradiation unit 20.
- [0130] As mentioned above, the supporting apparatus 10 may further comprise a purge gas means 104 configured to provide purge gas to the irradiation light enclosure structure 18 and/or the irradiation unit 20.
- [0131] The purge gas means 104 may be a purge gas supplying apparatus.
- [0132] The purge gas means 104 may be a purge gas feeding device.
- [0133] The purge gas may be a noble gas or inert gas, such as nitrogen or argon.
- [0134] With the configuration according to which the supporting apparatus 10 may further comprise a purge gas means 104 configured to provide purge gas to the irradiation light enclosure structure 18 and/or the irradiation unit 20, the irradiation light beam is protected from external influences, such as water vapor, dust particles, or other constituent parts of ambient air, which may settle on the surfaces of optical components used in the processing system 1, thereby allowing for improved processing by the irradiation light.
- [0135] Fig. 14 is a schematic illustration of a vibration reduction means 300 of a processing system 1 according to the present disclosure. The vibration reduction means 300 is for reducing vibration of the supporting apparatus 10. In general, at least one of the first base member 11, the second base member 12, the carrier member 13, the irradiation unit 20, and the holding unit 14 may comprise a vibration reduction means 300 for reducing vibration of the supporting apparatus 10.
- [0136] Fig. 14 shows an example in which the vibration reduction means 300 is disposed between the movable platform 111 of the first base member 11 and the carrier member 13. In Fig. 14, the vibration reduction means 300 is a passive vibration reduction means. In Fig. 14(a), the passive vibration reduction means comprises a rubber element 301, disposed between the carrier member 13 and the movable platform 111. In Fig. 14(b), the passive vibration reduction means comprises a springs 302, disposed between the carrier member 13 and the movable platform 111.

- [0137] Fig. 15 is a schematic illustration of another vibration reduction means 300 of a processing system 1 according to the present disclosure. Fig. 15 shows an example in which the vibration reduction means 300 is disposed between the movable platform 111 of the first base member 11 and the carrier member 13. In Fig. 15, the vibration reduction means 300 is an active vibration reduction means. The active vibration reduction means comprises a sensor 303 configured to detect a vibration of the supporting apparatus 10, for example, a vibration in the third direction, and an actuator 304 configured to move a vibrating part of the supporting apparatus 10 based on a detection signal of the sensor 303 to thereby compensate a vibration of the supporting apparatus 10. In the example of Fig. 15, the actuator 304 is configured to move the carrier member 13 as an example of a vibrating part of the supporting apparatus 10. The active vibration reduction means may involve an active drive mechanism that uses hydraulics, pneumatics, piezo-electric, or other techniques.
- [0138] As mentioned above, at least one of the first base member 11, the second base member 12, the carrier member 13, the irradiation unit 20, and the holding unit 14 may comprise a vibration reduction means 300 for reducing vibration of the supporting apparatus 10.
- [0139] The vibration reduction means 300 may be a vibration reduction apparatus.
- [0140] The vibration reduction means 300 may be a vibration reduction device.
- [0141] The vibration reduction means 300 may be a vibration isolation apparatus.
- [0142] The vibration reduction means 300 may be a vibration isolation device.
- [0143] The vibration reduction means 300 may have a combination of the passive vibration reduction means shown in Fig. 14, and the active vibration reduction means shown in Fig. 15. For example, the techniques disclosed, for example, in US Pat. Nos. 6,816,232 and 6,894,449 may be applied to the vibration reduction means 300.
- [0144] With the configuration according to which at least one of the first base member 11, the second base member 12, the carrier member 13, the irradiation unit 20, and the holding unit 14 may comprise a vibration reduction means 300 for reducing vibration of the supporting apparatus 10, vibrations of the processing system 1 can be reduced, thereby improving the accuracy of the processing system 1. For example, vibrations of the processing system 1 can occur due to wind, walking persons, moving machines, such as landing aircrafts, and the like.
- [0145] For example, the holding unit 14 and/or the irradiation unit 20 may comprise a vibration reduction means 300 for reducing vibration between the holding unit 14 and the irradiation unit 20. In particular, such vibration reduction means 300 for reducing vibration between the holding unit 14 and the irradiation unit 20 may be the only vibration reduction means 300 comprised in the processing system 1. This reduces the total weight of the part of the processing system 1 that needs to be vibration isolated,

which makes the configuration of the processing system 1 easier. Also, vibration sources close to the holding unit 14 and the irradiation unit 20 are outside the vibration isolated area then and can also be compensated by the vibration reduction means 300.

- [0146] As mentioned above, the vibration reduction means 300 may comprise passive vibration reduction means 300 comprising rubber elements 301 and/or springs, and/or active vibration reduction means 300 comprising a sensor 303 configured to detect a vibration of the supporting apparatus 10 and an actuator 304 configured to move a vibrating part of the supporting apparatus 10 based on a detection signal of the sensor 303 to thereby compensate a vibration of the supporting apparatus 10.
- [0147] The passive vibration reduction means 300 may be a passive vibration reduction apparatus.
- [0148] The passive vibration reduction means 300 may be a passive vibration reduction device.
- [0149] The passive vibration reduction means 300 may be a passive vibration isolation apparatus.
- [0150] The passive vibration reduction means 300 may be a passive vibration isolation device.
- [0151] The active vibration reduction means 300 may be an active vibration reduction apparatus.
- [0152] The active vibration reduction means 300 may be an active vibration reduction device.
- [0153] The active vibration reduction means 300 may be an active vibration isolation apparatus.
- [0154] The active vibration reduction means 300 may be an active vibration isolation device.
- [0155] The rubber elements 301 and/or springs may be provided at movable parts that are movable with respect to other parts of the first base member 11, the second base member 12, the carrier member 13, the irradiation unit 20, and the holding unit 14. For example, the irradiation unit 20 may comprise several movable parts, such as plates, which are prone to vibration. Using rubber elements 301 at these movable parts, such as rubber feet, the vibration of these movable parts can be reduced.
- [0156] Further passive vibration reduction techniques, which may include other types of vibration dampers, shock absorbers, and base isolation are possible.
- [0157] The sensor 303 of the active vibration reduction means 300 may be an acceleration sensor configured to measure acceleration in the three degrees of freedom to thereby detect an acceleration of a moving part due to vibration of the supporting apparatus 10. In other words, the acceleration sensor is configured to detect a vibration of the supporting apparatus 10. The acceleration sensor may then output this vibration

detection signal to an actuator 304, which may involve an active drive mechanism, which may use hydraulics, pneumatics, piezo-electric, or other techniques, the actuator 304 being configured to move a vibrating part of the supporting apparatus 10 based on the detection signal to thereby compensate the vibration of the supporting apparatus 10. Compensation may be realized by an active application of force in an equal and opposite fashion to the forces imposed by external vibration. Thus, the active vibration reduction means 300 actively reduces the amount of vibration of the supporting apparatus 10.

- [0158] The active vibration reduction means 300 may include an electronic amplifier system that is configured to amplify and invert the signals from the acceleration sensor. Moreover, a PID controller may be used to improve performance as opposed to a case using a simple inverting amplifier.
- [0159] A control unit may be provided that functionally connects the sensor 303 of the active vibration reduction means 300 with the actuator 304 of the active vibration reduction means 300, for example, by processing signals so as to cause the activation vibration reduction means 300 to compensate the vibration. The control unit may be part of the processing system 1.
- [0160] In case of an aircraft as the object 2 to be processed, wherein a riblet structure is to be formed in the aircraft paint, vibration reduction is desirable especially in the second direction, which is the direction crossing the first direction and, thus, the direction crossing the extending direction of the parallel riblet structure. This is in order to ensure that the riblets run in parallel to each other, which is desirable for a proper functioning of the riblet structure in order to reduce drag.
- [0161] With the configuration according to which the vibration reduction means 300 may comprise passive vibration reduction means 300 comprising rubber elements 301 and/or springs, and/or active vibration reduction means 300 comprising a sensor 303 configured to detect a vibration of the supporting apparatus 10 and an actuator 304 configured to move a vibrating part of the supporting apparatus 10 based on a detection signal of the sensor 303 to thereby compensate a vibration of the supporting apparatus 10, vibration of the processing system 1 can be passively and/or actively reduced, to thereby improve accuracy of the processing system 1.
- [0162] Fig. 16 is a schematic illustration of a tracking system 105 and a rotation mount 142 of a processing system 1 according to the present disclosure. In the embodiment shown in Fig. 16, the tracking system 105 has two cameras as an example of an optical tracking system 105 configured to track a movement of the holding unit 14 relative to the object 2 to be irradiated along the first, second, and third direction. In the present case, the object 2 to be irradiated is a wing of an aircraft.
- [0163] As mentioned above, the supporting apparatus 10 may further comprise a tracking

system 105 configured to track a movement of the holding unit 14 relative to the object 2 to be irradiated along the first, second, and/or third direction. The tracking system 105 may track the movement of characteristic (feature) point(s) on the surface of the irradiation object 2, marks on the surface of the irradiation object 2, or riblet structures already formed on the irradiation object 2.

[0164] The tracking system 105 may be a standard tracking system 105 including a closed loop system. The tracking system 105 may be an optical system. The tracking system 105 may be a monitoring device configured to measure properties of the surface, such as optical properties.

[0165] For example, in case of an aircraft as the object 2 to be processed, wherein the riblet structure is to be formed in the aircraft paint, it is desirable to precisely track the movement of the holding unit 14 and, thus, of the irradiation unit 20 along the second direction for avoiding that the same area is processed twice. Otherwise, there is a risk that the aircraft paint is removed completely. Using an optical system as the tracking system 105, the already processed surface portions can be easily distinguished from not yet processed surface portions. For example, in some cases, the processed surface portions may be less reflective, or may have a different quality of reflection, as compared with unprocessed surface portions. On the other hand, the depth of field of laser interference pattern may be much larger than a width or spacing of the riblets, for example about 2 cm. Accordingly, the precision in the third direction may not need to be as high as, for example, in the second direction.

[0166] In addition, the processing system 1 may also comprise a localizer system that is configured to indicate to a user or a control unit configured to control the processing system 1 a position with respect to the object 2 to be processed that the processing system 1 must adopt.

[0167] With the configuration according to which the supporting apparatus 10 may further comprise a tracking system 105 configured to track a movement of the holding unit 14 relative to the object 2 to be irradiated along the first, second, and/or third direction, the object 2 can be processed automatically and reliably.

[0168] The holding unit 14 of the embodiment shown in Fig. 16 comprises a rotation mount 142. The rotation mount 142 is configured to rotatably hold the irradiation unit 20. In the embodiment shown in Fig. 16, the rotation mount 142 rotatably holds the irradiation unit 20 so that it can rotate around a rotation axis that is perpendicular to the first direction and to the third direction.

[0169] As mentioned above, the holding unit 14 may comprise a rotation mount 142 configured to rotatably hold the irradiation unit 20.

[0170] For example, as mentioned above, the irradiation unit 20 may be rotatable relative to the carrier member 13 around an axis perpendicular to the longitudinal axis of the

carrier member 13. Moreover, the rotation mount 142 may be configured to rotatably hold the irradiation unit 20 so that the irradiation unit 20 is rotatable relative to the carrier member 13 around an axis that is not perpendicular to the longitudinal axis of the carrier member 13, but that crosses the longitudinal axis of the carrier member 13 at an angle, such as an angle of 30° to 60°, or 40° to 50°. In the case of an aircraft as the object 2 to be processed, such a configuration may be particularly suitable for processing the nose of the aircraft, for example, when the supporting apparatus 10 is in the second configuration, i.e., when the supporting apparatus 10 adopts a cantilever structure.

- [0171] With the configuration according to which the holding unit 14 may comprise a rotation mount 142 configured to rotatably hold the irradiation unit 20, the flexibility of the processing system 1 is further improved.
- [0172] A movement range of the holding unit 14 along the first direction may be between 3 m and 20 m, preferably between 5 m and 15 m, more preferably 6 m, and/or a movement range of the carrier member 13 along the second direction may be between 0.1 m and 7 m, preferably between 1 m and 5 m, more preferably 1.5 m. With this configuration, it is possible to form large patches, wherein a patch consists of two or more lanes of riblets, arranged in parallel to each other, without the need to rearrange the first base member 11 and the second base member 12 with respect to the object 2. Hence, with this configuration, it may become possible to more quickly process the object 2, thereby saving costs.
- [0173] The irradiation light may be laser light, wherein the irradiation unit 20 may be configured to produce a laser light interference pattern on the surface of the object 2. With this configuration, using laser light, the processing system 1 is able to perform the riblet structure in the aircraft paint of the aircraft. Moreover, since the irradiation unit 20 is configured to produce a laser light interference pattern on the surface of the object 2, it is possible to form the riblet structure more quickly by not only forming one, but multiple parallel grooves in the aircraft paint at the same time when moving the laser beam over the surface.
- [0174] The laser light may have a power of more than 500 W and a wavelength of between 8 micrometers and 12 micrometers, preferably wherein the laser light may be produced by a carbon-dioxide laser. With this configuration, especially in case the object 2 to be processed is an aircraft, wherein a riblet structure is to be formed in the aircraft paint, the riblet structure can be processed with high precision and accuracy. This is because a laser having the above-mentioned power and wavelength, such as a carbon-dioxide laser, is particularly suitable for processing polyurethane systems, epoxy systems, or acrylic systems, which may be conventionally used as aircraft paints.
- [0175] Next, a method for modifying a surface of an object 2 according to an embodiment of

the present disclosure will be described with reference to Figs. 4 and 5, in which the object 2 is a wing of an aircraft. The method comprises providing the processing system 1 according to the present disclosure, positioning the processing system 1 relative to the surface of the object 2, and modifying the surface of the object 2 by irradiating the surface of the object 2 with the irradiation light to form a surface structure, such as a riblet structure.

- [0176] Since the method uses the processing system 1 according to the present disclosure, it may be possible to modify a surface of an object with an improved accuracy and with high flexibility.
- [0177] As mentioned above, there is provided a method for modifying a surface of an object 2. The method may comprise providing the processing system 1 according to the present disclosure. The method may comprise positioning the processing system 1 relative to the surface. The method may comprise modifying the surface by irradiating the surface with the irradiation light to form a surface structure. When such a method uses the processing system 1 according to the present disclosure, it may be possible to modify a surface of an object 2 with an improved accuracy and with high flexibility.
- [0178] In the method for modifying a surface of an object 2, as shown in Fig. 5, the object 2 can be positioned between the first base member 11 and the second base member 12, or, as shown in Fig. 4, the first and second base members 11, 12 can be positioned on the same side of the object 2.
- [0179] As mentioned above, the object 2 may be positioned between the first base member 11 and the second base member 12, or the first and second base members 11, 12 may be positioned on the same side of the object 2.
- [0180] In a method, in which the object 2 is positioned between the first base member 11 and the second base member 12, the supporting apparatus 10 of the processing system 1 may be used in the first configuration, i.e., in the gantry configuration. In a method, in which the first and second base members 11, 12 are positioned on the same side of the object 2, the supporting apparatus 10 of the processing system 1 may be used in the second configuration, i.e., in the cantilever configuration. With this method, the surface of the object 2 can be modified with high flexibility and accuracy.
- [0181] It is to be understood that, even though the above discussion primarily focuses on a processing system for processing an aircraft by irradiating the aircraft with laser light and a method for modifying a surface of an aircraft to form a riblet structure, the concepts are equally applicable to processing systems for processing another object by irradiating the object with irradiation light and methods for modifying a surface of another object, in particularly where accuracy and flexibility are important. Examples for other objects include helicopters and helicopter blades, ships, land vehicles, turbine blades, and pipelines.

- [0182] Fig. 17 shows further examples of objects 2, the surfaces of which can be processed by a processing system 1 and by a method for modifying a surface of an object according to the present disclosure. As shown in Fig. 17, the surface of the object to be processed is, for example, a surface of a helicopter blade 401, a surface of a ship 402, a surface of a land vehicle 403, a surface of a turbine blade 404, or a surface of a pipeline 405. Note that, when the surface of the object to be processed is the surface of a ship 402, typically a surface below a waterline of the ship 402 is processed. The ship 402 may therefore be processed at a dry dock. At this time, the irradiation unit 20 may irradiate the processing beam upward or sideward.
- [0183] As mentioned above, the surface may be a surface of an aircraft, a surface of a helicopter blade, a surface of a ship, a surface of a land vehicle, a surface of a turbine blade, or a surface of a pipeline. The surface may be an exterior surface. When the surface is a surface of a pipeline, the surface may be an interior surface of the pipeline.
- [0184] As mentioned above, the processing system forms, on the object 2, the riblet structure for reducing the resistance of the surface of the object 2 to the fluid. However, the processing system may form, on the object 2, another structure that is different from the riblet structure for reducing the resistance of the surface to the fluid. For example, the processing system may form, on the object 2, a riblet structure for reducing a noise generated when the fluid and the surface of the object 2 relatively move. For example, the processing system may form, on the object 2, a structure for generating a swirl in a flow of the fluid on the surface of the object 2. For example, the processing system may form, on the object 2, a structure for giving a hydrophobic property to the object 2.

LIST OF REFERENCE SIGNS

- [0185] 1 Processing system
 2 Object
 21 Aircraft turbine
 22 Aircraft fuselage
 10 Supporting apparatus
 20 Irradiation unit
 201 Irradiation source
 11 First base member
 12 Second base member
 102 Third base member
 1021 Movable platform (of third base member)
 103 Fourth base member
 1031 Movable platform (of fourth base member)
 13 Carrier member

131 First end (of carrier member)
132 Second end (of carrier member)
14 Holding unit
141 Electronic component box
142 Rotation mount
15 Light input location
16 Light output location
17 Light conveying system
111 Movable platform (of first base member)
121 Movable platform (of second base member)
112 Wheel (of first base member)
122 Wheel (of second base member)
113 Telescopic configuration (of first base member)
123 Telescopic configuration (of second base member)
114 Chain (of first base member)
124 Chain (of second base member)
18 Irradiation light enclosure structure
104 Purge gas means
1041 Purge gas container
1042 Purge gas line
105 Tracking system
181 Folding bellows
182 Rigid structure
1821 Wall (of rigid structure)
1822 Textured structure
101 Linear motor drive
300 Vibration reduction means
301 Rubber element
302 Spring
303 Sensor (of active vibration reduction means)
304 Actuator (of active vibration reduction means)
19 Connection structure
B Irradiation light beam
401 Helicopter blade
402 Ship
403 Land vehicle
404 Turbine blade
405 Pipeline

[0186] According to the present disclosure, the following is provided:

Item 1. A processing system (1) for processing an object (2) by irradiating the object (2) with irradiation light, the processing system (1) comprising:

a supporting apparatus (10), and

an irradiation unit (20) movably supported by the supporting apparatus (10) and configured to irradiate the object (2) with the irradiation light,

the supporting apparatus (10) comprising:

at least a first base member (11) and a second base member (12), at least one of the first and second base members (11, 12) being movable with respect to the other one of the first and second base members (11, 12),

a carrier member (13) held by the first base member (11) and the second base member (12) and having a first end (131) and a second end (132), and

a holding unit (14) configured to hold the irradiation unit (20),

wherein the supporting apparatus (10) is convertible at least between a first configuration and a second configuration, wherein

in the first configuration, the holding unit (14) is positionable at the carrier member (13) between the first base member (11) and the second base member (12) so that one of the first and second base members (11, 12) is positioned closer to one of the first and second ends (131, 132) than the holding unit (14) and the other one of the first and second base members (11, 12) is positioned closer to the other one of the first and second ends (131, 132) than the holding unit (14),

in the second configuration, at least one of the first end (131) and the second end (132) of the carrier member (13) protrudes from the respective one of the first and second base members (11, 12), and the holding unit (14) is positionable at the carrier member (13) so that one of the first and second base members (11, 12) is positioned between the other one of the first and second base members (11, 12) and the holding unit (14).

Item 2. The processing system (1) according to item 1,

wherein both of the first and second base members (11, 12) are movable with respect to each other.

Item 3. The processing system (1) according to item 1 or 2,

wherein the first and second base members (11, 12) extend in an extending direction that crosses a floor surface on that the first and second base members (11, 12) are placeable.

Item 4. The processing system (1) according to item 3,

wherein the carrier member (13) is extended in a direction which crosses the extending direction of the first and second base members (11, 12).

Item 5. The processing system (1) according to any one of the preceding items,

wherein the supporting apparatus (10) further comprises
a light input location (15) and a light output location (16),
a light conveying system (17) arranged to convey the irradiation light from the light input location (15) to the light output location (16), the light input location (15) being for receiving the irradiation light into the light conveying system (17) and the light output location (16) being for outputting the irradiation light from the light conveying system (17), wherein
the holding unit (14) is configured to hold the irradiation unit (20) at a position for outputting the irradiation light from the light output location (16) into the irradiation unit (20).

Item 6. The processing system (1) according to any one of the preceding items,
wherein the holding unit (14) is movably held by the carrier member (13) so as to be movable along a first direction, the first direction being parallel or oblique to a direction from the first end (131) to the second end (132) of the carrier member (13),
and
wherein the carrier member (13) is movably held by the first and second base members (11, 12) so as to be movable along a second direction that crosses the first direction, and so as to be movable along a third direction that crosses the first and second directions.

Item 7. The processing system (1) according to item 6,
wherein the first and second base members (11, 12) comprise a movable platform (111, 121) on which the carrier member (13) is disposed for moving the carrier member (13) along the third direction and/or have a telescopic configuration (113, 123) for moving the carrier member (13) along the third direction.

Item 8. The processing system (1) according to item 6 or 7,
wherein the supporting apparatus (10) further comprises a linear motor drive (101) for movement of the holding unit (14) in the first direction.

Item 9. The processing system (1) according to any one of the preceding items,
wherein each of the first base member and the second base member (11, 12) is provided with wheels (112, 122) or chains (114, 124) for moving the first and second base members (11, 12) over a floor.

Item 10. The processing system (1) according to any one of the preceding items,
wherein the supporting apparatus (10) further comprises a third and a fourth base member (102, 103) as a substitution for the first and second base members (11, 12),
wherein the third and fourth base members (102, 103) have a different height than the first and second base members (11, 12).

Item 11. The processing system (1) according to any one of the preceding items,
wherein the supporting apparatus (10) further comprises an irradiation source (201)

configured to produce the irradiation light.

Item 12. The processing system (1) according to any one of the preceding items, wherein the supporting apparatus (10) further comprises an irradiation light enclosure structure (18) for at least partly enclosing an irradiation light beam (B).

Item 13. The processing system (1) according to item 12, wherein the irradiation light enclosure structure (18) comprises a folding bellows (181) and a rigid structure (182), the folding bellows (181) being at least partly surrounded by the rigid structure (182),

wherein the rigid structure (182) comprises differently oriented walls (1821) so as to have, in its cross-sectional profile, at least two, preferably at least three, corners, and has a textured structure (1822) on a surface facing the folding bellows (181), the textured structure (1822) being configured to diffusely reflect the processing light.

Item 14. The processing system (1) according to item 12 or 13, wherein the supporting apparatus (10) further comprises a purge gas means (104) configured to provide purge gas to the irradiation light enclosure structure (18) and/or the irradiation unit (20).

Item 15. The processing system (1) according to any one of the preceding items, wherein at least one of the first base member (11), the second base member (12), the carrier member (13), the irradiation unit (20), and the holding unit (14) comprises a vibration reduction means (300) for reducing vibration of the supporting apparatus (10).

Item 16. The processing system (1) according to item 15, wherein the vibration reduction means (300) comprises passive vibration reduction means comprising rubber elements (301) and/or springs (302), and/or active vibration reduction means comprising a sensor (303) configured to detect a vibration of the supporting apparatus (10) and an actuator (304) configured to move a vibrating part of the supporting apparatus (10) based on a detection signal of the sensor (303) to thereby compensate a vibration of the supporting apparatus (10).

Item 17. The processing system (1) according to any one of items 6 to 16, wherein the supporting apparatus (10) further comprises a tracking system (105) configured to track a movement of the holding unit (14) relative to the object (2) to be irradiated along the first, second, and/or third direction.

Item 18. The processing system (1) according to any one of the preceding items, wherein the carrier member (13) is rotatably held by the first and second base members (11, 12) so as to be rotatable around a rotation axis, the rotation axis being parallel to a direction from the first end (131) to the second end (132) of the carrier member (13).

Item 19. The processing system (1) according to any one of the preceding items,

wherein the holding unit (14) is configured to hold the irradiation unit (20) at opposite sides of the carrier member (13), the opposite sides being opposite in a direction perpendicular to a direction from the first end (131) to the second end (132) of the carrier member (13).

Item 20. The processing system (1) according to any one of the preceding items, wherein the holding unit (14) comprises a rotation mount (142) configured to rotatably hold the irradiation unit (20).

Item 21. The processing system (1) according to any one of items 6 to 20, wherein a movement range of the holding unit (14) along the first direction is between 3 m and 20 m, preferably between 5 m and 15 m, more preferably 6 m, and a movement range of the carrier member (13) along the second direction is between 0.1 m and 7 m, preferably between 1 m and 5 m, more preferably 1.5 m.

Item 22. The processing system (1) according to any one of the preceding items, wherein the irradiation light is laser light, wherein the irradiation unit is configured to produce a laser light interference pattern on the surface of the object (2).

Item 23. The processing system (1) according to item 22, wherein the laser light has a power of more than 500 W and a wavelength of between 8 micrometers and 12 micrometers, preferably wherein the laser light is produced by a carbon-dioxide laser.

Item 24. The processing system (1) according to any one of preceding items, wherein a size of the processing system (1) is smaller than a size of the object (2).

Item 25. A method for modifying a surface of an object (2), the method comprising:

- providing the processing system (1) according to any one of the preceding items,
- positioning the processing system (1) relative to the surface,
- modifying the surface by irradiating the surface with the irradiation light to form a surface structure.

Item 26. The method of item 25,

wherein the object (2) is positioned between the first base member (11) and the second base member (12), or

wherein the first and second base members (11, 12) are positioned on the same side of the object (2).

Item 27. The method according to item 25 or 26,

wherein the surface is a surface of an aircraft, a surface of a helicopter blade (401), a surface of a ship (402), a surface of a land vehicle (403), a surface of a turbine blade (404), or a surface of a pipeline (405).

Item 28. The method according to any one of items 25 to 27, wherein the object (2) is a movable body.

Item 29. The method according to item 28, wherein the movable body moves in a fluid.

Claims

- [Claim 1] A processing system (1) for processing an object (2) by irradiating the object (2) with irradiation light, the processing system (1) comprising: a supporting apparatus (10), and an irradiation unit (20) movably supported by the supporting apparatus (10) and configured to irradiate the object (2) with the irradiation light, the supporting apparatus (10) comprising: at least a first base member (11) and a second base member (12), at least one of the first and second base members (11, 12) being movable with respect to the other one of the first and second base members (11, 12), a carrier member (13) held by the first base member (11) and the second base member (12) and having a first end (131) and a second end (132), and a holding unit (14) configured to hold the irradiation unit (20), wherein the supporting apparatus (10) is convertible at least between a first configuration and a second configuration, wherein in the first configuration, the holding unit (14) is positionable at the carrier member (13) between the first base member (11) and the second base member (12) so that one of the first and second base members (11, 12) is positioned closer to one of the first and second ends (131, 132) than the holding unit (14) and the other one of the first and second base members (11, 12) is positioned closer to the other one of the first and second ends (131, 132) than the holding unit (14), in the second configuration, at least one of the first end (131) and the second end (132) of the carrier member (13) protrudes from the respective one of the first and second base members (11, 12), and the holding unit (14) is positionable at the carrier member (13) so that one of the first and second base members (11, 12) is positioned between the other one of the first and second base members (11, 12) and the holding unit (14).
- [Claim 2] The processing system (1) according to claim 1, wherein both of the first and second base members (11, 12) are movable with respect to each other.
- [Claim 3] The processing system (1) according to claim 1 or 2, wherein the first and second base members (11, 12) extend in an extending direction that crosses a floor surface on that the first and

- second base members (11, 12) are placeable.
- [Claim 4] The processing system (1) according to claim 3, wherein the carrier member (13) is extended in a direction which crosses the extending direction of the first and second base members (11, 12).
- [Claim 5] The processing system (1) according to any one of the preceding claims, wherein the supporting apparatus (10) further comprises a light input location (15) and a light output location (16), a light conveying system (17) arranged to convey the irradiation light from the light input location (15) to the light output location (16), the light input location (15) being for receiving the irradiation light into the light conveying system (17) and the light output location (16) being for outputting the irradiation light from the light conveying system (17), wherein the holding unit (14) is configured to hold the irradiation unit (20) at a position for outputting the irradiation light from the light output location (16) into the irradiation unit (20).
- [Claim 6] The processing system (1) according to any one of the preceding claims, wherein the holding unit (14) is movably held by the carrier member (13) so as to be movable along a first direction, the first direction being parallel or oblique to a direction from the first end (131) to the second end (132) of the carrier member (13), and wherein the carrier member (13) is movably held by the first and second base members (11, 12) so as to be movable along a second direction that crosses the first direction, and so as to be movable along a third direction that crosses the first and second directions.
- [Claim 7] The processing system (1) according to claim 6, wherein the first and second base members (11, 12) comprise a movable platform (111, 121) on which the carrier member (13) is disposed for moving the carrier member (13) along the third direction and/or have a telescopic configuration (113, 123) for moving the carrier member (13) along the third direction.
- [Claim 8] The processing system (1) according to claim 6 or 7, wherein the supporting apparatus (10) further comprises a linear motor drive (101) for movement of the holding unit (14) in the first direction.
- [Claim 9] The processing system (1) according to any one of the preceding

- claims,
wherein each of the first base member and the second base member (11, 12) is provided with wheels (112, 122) or chains (114, 124) for moving the first and second base members (11, 12) over a floor.
- [Claim 10] The processing system (1) according to any one of the preceding claims,
wherein the supporting apparatus (10) further comprises a third and a fourth base member (102, 103) as a substitution for the first and second base members (11, 12), wherein the third and fourth base members (102, 103) have a different height than the first and second base members (11, 12).
- [Claim 11] The processing system (1) according to any one of the preceding claims,
wherein the supporting apparatus (10) further comprises an irradiation source (201) configured to produce the irradiation light.
- [Claim 12] The processing system (1) according to any one of the preceding claims,
wherein the supporting apparatus (10) further comprises an irradiation light enclosure structure (18) for at least partly enclosing an irradiation light beam (B).
- [Claim 13] The processing system (1) according to claim 12,
wherein the irradiation light enclosure structure (18) comprises a folding bellows (181) and a rigid structure (182), the folding bellows (181) being at least partly surrounded by the rigid structure (182), wherein the rigid structure (182) comprises differently oriented walls (1821) so as to have, in its cross-sectional profile, at least two, preferably at least three, corners, and has a textured structure (1822) on a surface facing the folding bellows (181), the textured structure (1822) being configured to diffusely reflect the processing light.
- [Claim 14] The processing system (1) according to claim 12 or 13,
wherein the supporting apparatus (10) further comprises a purge gas means (104) configured to provide purge gas to the irradiation light enclosure structure (18) and/or the irradiation unit (20).
- [Claim 15] The processing system (1) according to any one of the preceding claims,
wherein at least one of the first base member (11), the second base member (12), the carrier member (13), the irradiation unit (20), and the holding unit (14) comprises a vibration reduction means (300) for

- reducing vibration of the supporting apparatus (10).
- [Claim 16] The processing system (1) according to claim 15, wherein the vibration reduction means (300) comprises passive vibration reduction means comprising rubber elements (301) and/or springs (302), and/or active vibration reduction means comprising a sensor (303) configured to detect a vibration of the supporting apparatus (10) and an actuator (304) configured to move a vibrating part of the supporting apparatus (10) based on a detection signal of the sensor (303) to thereby compensate a vibration of the supporting apparatus (10).
- [Claim 17] The processing system (1) according to any one of claims 6 to 16, wherein the supporting apparatus (10) further comprises a tracking system (105) configured to track a movement of the holding unit (14) relative to the object (2) to be irradiated along the first, second, and/or third direction.
- [Claim 18] The processing system (1) according to any one of the preceding claims, wherein the carrier member (13) is rotatably held by the first and second base members (11, 12) so as to be rotatable around a rotation axis, the rotation axis being parallel to a direction from the first end (131) to the second end (132) of the carrier member (13).
- [Claim 19] The processing system (1) according to any one of the preceding claims, wherein the holding unit (14) is configured to hold the irradiation unit (20) at opposite sides of the carrier member (13), the opposite sides being opposite in a direction perpendicular to a direction from the first end (131) to the second end (132) of the carrier member (13).
- [Claim 20] The processing system (1) according to any one of the preceding claims, wherein the holding unit (14) comprises a rotation mount (142) configured to rotatably hold the irradiation unit (20).
- [Claim 21] The processing system (1) according to any one of claims 6 to 20, wherein a movement range of the holding unit (14) along the first direction is between 3 m and 20 m, preferably between 5 m and 15 m, more preferably 6 m, and a movement range of the carrier member (13) along the second direction is between 0.1 m and 7 m, preferably between 1 m and 5 m, more preferably 1.5 m.

- [Claim 22] The processing system (1) according to any one of the preceding claims,
wherein the irradiation light is laser light, wherein the irradiation unit is configured to produce a laser light interference pattern on the surface of the object (2).
- [Claim 23] The processing system (1) according to claim 22,
wherein the laser light has a power of more than 500 W and a wavelength of between 8 micrometers and 12 micrometers, preferably wherein the laser light is produced by a carbon-dioxide laser.
- [Claim 24] A method for modifying a surface of an object (2), the method comprising:
- providing the processing system (1) according to any one of the preceding claims,
- positioning the processing system (1) relative to the surface,
- modifying the surface by irradiating the surface with the irradiation light to form a surface structure.
- [Claim 25] The method of claim 24,
wherein the object (2) is positioned between the first base member (11) and the second base member (12), or
wherein the first and second base members (11, 12) are positioned on the same side of the object (2).
- [Claim 26] The method according to claim 24 or 25,
wherein the surface is a surface of an aircraft, a surface of a helicopter blade (401), a surface of a ship (402), a surface of a land vehicle (403), a surface of a turbine blade (404), or a surface of a pipeline (405).