



A METHOD AND SYSTEM OF TREATING A SURFACE OF A FABRICATED MICRO-COMPONENT

FIELD OF THE INVENTION

The present invention relates to a method and system of treating a surface of a fabricated micro-component, and in particular for creating a desired surface finishes on selected regions of fabricated micro-components for tribological performances.

BACKGROUND OF THE INVENTION

The demand for and utilisation of small and compact mechanisms is increasing due to the requirements of mobile devices and products. Many technologies have been explored and tested for providing micro-scale fabrication and the ability to generate and process complex designs, geometry shapes, materials and surfaces. Many fabrication processes (such as deep reactive ion etch [DRIE], grinding, laser cutting) used to make micro-components and devices from various materials (such as semi-conductors, metals, alloys, ceramics and polymers) often result in rough surface finishing. Such rough surfaces produce high abrasion, heat and noise when used for tribological applications such as sliding and rotating motions. These characteristics are undesirable as they shorten the lifetime of the micro-components or devices.

Although the application of further processes such as thin film coating, diamond-like carbon (DLC) coating, polymer coating and chemical processing has been tried on the fabricated micro-component surfaces, they may result in coating film failure or may only provide a short term improvement. These further processes generally faced adhesion problem with the rough surfaces and are not strong enough for the tribological performances of the micro-component or device.



Another problem of conventional fabricated micro-components and devices is their small size and that the surface which needs to be processed may be difficult to reach. Also, the surfaces to be processed may not be planar. Conventional machining techniques for improving these surfaces are cumbersome, inefficient, and often produce unacceptable quality. Moreover, conventional chemical or mechanical treatments do not achieve precise tolerances, which render such processes unsuitable for improving the predetermined surface region of the micro-component or device.

In view of the foregoing problems requirements, a need exists for a method and/or system for a surface treatment to produce a surface finish for fabricated micro-components which does not suffer from the above disadvantages.

SUMMARY OF THE INVENTION

In general, the present invention relates to a method of treating a surface of a fabricated micro-specimen by irradiating the surface of the specimen using an infrared (IR) wavelength laser, and a system for treating a surface of a fabricated micro-specimen using an infrared (IR) wavelength laser to irradiate the surface.

According to a first aspect of the present invention there is provided a method of treating a surface of a fabricated micro-specimen comprising irradiating said surface of said specimen using an infrared (IR) wavelength laser to melt one or more asperities in said surface to smooth said surface.

According to a second aspect of the present invention there is provided a system to treat a surface of a fabricated micro-specimen comprising a mounting device on which said specimen to be treated is mountable, and an infrared (IR) wavelength laser for irradiating said surface of said specimen, said laser being arranged to melt one or more asperities in said surface to smooth said surface.

According to a third aspect of the present invention there is provided a method of treating a surface of a fabricated micro-specimen comprising irradiating said surface of said specimen using an infrared (IR) wavelength laser to melt one or more asperities in said surface causing said surface to flow thereby reducing the amount of surface irregularity.

According to a fourth aspect of the present invention there is provided a system to treat a surface of a fabricated micro-specimen comprising a mounting device on which said specimen to be treated is mountable, and an infrared (IR) wavelength laser for irradiating said surface of said specimen, said laser being arranged to melt one or more asperities in said surface causing said surface to flow thereby reducing the amount of surface irregularity.

Furthermore, the use of an IR wavelength laser enables heat to penetrate the micro-component's surface causing it to melt and smooth its surface. Also, such an IR wavelength laser may provide good repeatability of surface finish for the specimens.

As laser treatments of the fabricated micro-components according to one or more preferred embodiments of the invention may reduce the roughness of the surfaces of the specimens, the bonding or adhesion strength between the treated surfaces and the coated or applied materials may be enhanced. Thus, processes such as thin film coating, DLC coating, polymer coating or other chemical processes may be further applied as an additional improvement for the tribological performances of the treated micro-components.

One or more preferred embodiments of the invention may also enable the laser treatment to create a desired surface finishing on selected regions of fabricated micro-components for tribological performances, such as sliding and rotating.

Additionally, one or more preferred embodiments of the invention may enable the treatment process to be implemented on varying types of surface such as a

planar surface, various circular surfaces (for example shaft, rod, ring, disk and plate), and other geometrically shaped surfaces (such as stepped, hexagonal and polygonal), as well as internal surfaces of thin planar and circular structured components (such as the internal sleeve surfaces of a ring, a disk or a plate).

Furthermore, the materials from which the specimens may be formed may be those used in semi-conductors (eg. silicon [Si], carbon), metals (eg. steel, aluminum), alloys (eg stainless steel), ceramics and polymers. The fabrication processes used to make the specimens may include DRIE, grinding, milling, laser cutting or other conventional machining techniques.

The surfaces of the specimens fabricated using processes such as DRIE, grinding and laser cutting will have different types of finishing/roughness and one or more preferred embodiments of the invention may enable the use and control of the laser power, the repetition pulse rate and the scanning speed (when galvanometer is used) of the laser equipment to melt the specimen's surface and obtain optimum (smooth) finishing.

Furthermore, one or more preferred embodiments of the invention may enable the treatment of surface of the fabricated micro-components to be conducted under ambient conditions, that is, atmospheric pressure and room temperature.

The fabricated micro-components are usually very small and the surface to be treated may be difficult to reach. Also, the surfaces to be treated may not be planar or flat (eg. circular). However, the mounting device may be fabricated for holding and guiding the fabricated micro-components to be treated.

As the fabricated micro-components may be used for tribological applications such as sliding and rotating motions, one or more preferred embodiments of the invention may enable the reduction of friction and thereby reduction of abrasion, heat and noise. Furthermore, the bonding and/or adhesion strength between the treated surfaces and the coated or applied materials may be enhanced.

Further processes such as thin film coating, diamond-like carbon (DLC) coating, polymer coating, or other chemical processes may be applied to the specimens after treatment and one or more preferred embodiments of the invention may enable a further reduction in friction in the tribological applications of the treated micro-components.

BRIEF DESCRIPTION OF THE DRAWINGS

Embodiments of the invention will now be described, by way of example, and with reference to the accompanying drawings, in which:

Figure 1 is a schematic diagram showing the structure of a system according to an embodiment of the invention;

Figure 2a is a schematic diagram of a mounting device for use with the system of Figure 1;

Figure 2b is a schematic diagram of a mounting device for use with small inner circular hole specimens and examples of modified shaft tips;

Figure 2c a schematic diagram of a further mounting device for use with the system of Figure 1;

Figure 3a is a schematic illustration of a series of examples of specimens for mounting in the device of Figure 2a and 2b for treatment; and

Figure 3b is a schematic illustration of a series of examples of specimens for mounting in the device of Figure 2c for treatment.

DETAILED DESCRIPTION OF PREFERRED EMBODIMENTS

Figure 1 shows a schematic diagram of a system according to a first preferred embodiment of the invention. The system comprises a mounting device 100, for holding a specimen (substrate) 101 to be treated. The mounting device 100 is mounted on a motion stage 200 and is arranged to be movable in the XYZ

directions, and to tilt and/or rotate together with the mounting device 100. The motion stage 200 has a goniometer facility for the tilting thereof. The system also includes an infrared (IR) wavelength laser source unit 300. The system may be controlled by computer 400 carrying application software for controlling the laser unit 300 and the motion stage 200. An alternative to moving the specimen 101 by the motion stage 200 is to scan the laser beam emitted from the laser source unit 300 across the specimen 101 using a galvanometer system 500.

In operation, the laser beam from the laser unit 300 may be directed to an objective lens 301 using mirror 302 and focused by the objective lens 301 onto the specimen 101 mounted in the mounting device 100, as shown in Figure 1, the mounting device 100 itself being mounted on the motion stage 200. If the laser beam is to be scanned by the galvanometer system 500, then the beam from the laser is focused onto the specimen 101 using an objective lens internal to the galvanometer system 500 rather than the objective lens of the laser system, which may be omitted in this embodiment, and the laser beam is directed onto the specimen using a galvanometer mirror, the motion of the galvanometer mirror being controlled by the computer 400 to produce a scanning action of the laser beam.

Figure 2a shows the features of a first embodiment of the mounting device 100 for use with the system of Figure 1 in the course of a laser treatment method applied to the specimen 101 to be treated which is mounted in the mounting device 100.

The mounting device 100 comprises a guide 102 which is carried on a first shaft 103. The first shaft 103 is arranged to rotate the specimen 101 about the longitudinal axis of the first shaft 103. A second shaft 104, which is spring-loaded, is provided with its longitudinal axis aligned with that of the first shaft 103 so that the specimen 101 is retained between the first and second shafts 103, 104. A holder 105 may be included in a further preferred embodiment to replace the first shaft 103. A motor 106 is mounted on a first block 107 and arranged to

drive the first shaft 103. The motor 106 may be, for example, a linear motor or a stepper motor, and the type of motor used may be dependent on the design and geometry of the specimen 101 to be treated and the procedure required for the treatment of the specimen. The mounting device 100 further includes a stage 108, which may be mounted on the motion stage 200 of the system of Figure 1. Thus, the guide 102, the first and second shafts 103 and 104, the holder 105, the motor 106 and the first block 107 may be carried on the stage 108.

The first block 107 houses the motor 106 and the first shaft 103 coupled thereto. The motor 106 drives the rotating motion of the specimen 101 about the longitudinal axis of the shaft 103. A second block 109 holds the spring-loaded second shaft 104 with its longitudinal axis aligned to that of the first shaft 103.

The second shaft 104 may be pulled back to allow the substrate 101 to be clamped in position prior to treatment. Also, the second block 109 may be adjusted or removed when it is not required. The spring load of the second shaft 104 which is located in the second block 109 may be adjusted to suit the different amounts of force required in clamping the specimen 101 in the mounting device 100.

The guide 102 which is located on either one or other of the first or second shafts 103, 104 has a slot for aligning the specimen 101 in position on the mounting device 100 prior to treatment. The guide 102 assists in enabling the laser treatment process to create a desirable and even surface finishing on selected regions of the specimen 101 when it is rotated. Furthermore, the guide 102 is removeably replaceable and therefore may be selected according to the specimen 101 to be treated.

A third block 110 is locatable on the stage 108 for use when performing a laser treatment process on fabricated micro-components that do not require rotating (such as plate and or a specimen having step geometry). The third block 110 may be removed when its use is not required.

Figure 2b shows the features of a second embodiment of the mounting device 100 for use with the system of Figure 1 in the course of a laser treatment method applied to a circular specimen 101 for laser treatment, when the circular specimen 101 has a small inner circular hole. The small inner circular hole is concentric with the central axis of the circular specimen 101. The small inner circular hole can be made during the process of fabricating the micro-specimen. With the small inner hole in the center of the circular micro-specimen, it allows modification of the tip of holding shaft 104. With the use of a modified (eg. rounded or pointed or tapered) tip, the micro-specimen can be self centered without the use of the guide 102. The small inner circular hole on specimen 101 enables the laser treatment process to create a desirable and even surface finishing on selected regions of the specimen 101 when it is rotated. The diameter or size of the tip for shaft 104 depends on the size of the small inner circular hole of specimen 101. The small inner hole could also be another shape (such as square or rectangular) as long as it is made with reference to the center point of the micro-specimen. The tip of the holding shaft 104 would then be modified appropriately to hold the specimen for the laser treatment.

Figure 2c shows the features of a third embodiment of the mounting device 100 for use with the system of Figure 1 in the course of a laser treatment method applied to the specimen 101 for laser treatment on internal surfaces of thin planar and/or circular structured specimens, for example on the internal sleeve surfaces of a ring, disk or plate. The components of the system of Figure 2b which correspond to the components of Figure 2a are denoted by the same reference numerals.

In the system of Figure 2c, when used for the laser treatment of internal surfaces of thin planar and/or circular structured specimens, the second block 109 together with the second shaft 104 may be removed from the stage 108. The first shaft 103 and the guide 102 may also be removed and replaced with the

holder 105. The holder 105 has a slot therein which receives the specimen 101 to be treated.

Figure 3a is a schematic illustration of a series of examples of specimens or 'substrates' for mounting in the device of Figure 2a and 2b for treatment. Figure 3b is a schematic illustration of a series of examples of specimens or 'substrates' for mounting in the device of Figure 2c for treatment.

The specimens of Figure 3a include cylindrical elements which may or may not have an aperture extending therethrough, and, for example, a triangular prism, a rectangular prism, an octagonal prism, an elliptical cylinder and an L-shaped (or step) prism.

The specimens of Figure 3b include cylindrical elements, rectangular prisms or substantially flat plate structures having an outer peripheral shape such as circular, rectangular or triangular. Each of the elements shown in Figure 3b has an aperture therethrough which may have a circular, rectangular or triangular peripheral shape. The apertures in the elements may extend part or all the way through the elements.

The laser power required to treat and improve the surface of a specimen 101 will depend on the roughness of the surface and the material of the specimen to be treated. Surfaces produced by mechanical micro-machining will generally have a rougher surface finish than those produced by DRIE or laser cutting and may require higher powers to heat and penetrate the depth of the specimen. As laser treatment is to be used on specimens of varying designs and geometry, the laser power required will also depend on the velocity that is both linear and rotational velocity, imposed by the motion stage 200 and the desired mounting device 100.

In a preferred embodiment, an IR wavelength laser unit 300 may be used for the laser treatment. An example of a suitable laser for use is a Nd:YAG laser having a laser wavelength of around 1064 nm with low pulse energy, a high repetitive

frequency of around 5 kHz, a pulse duration of about 100 ns and an output power in the range of around 10W to 100W. In further preferred embodiments, other IR wavelength lasers which have different characteristics or specifications may be used for the treatment and surface improvement process.

The specimens 101 may be treated according to one or more preferred embodiments of the invention as set out below.

As an example, in a first preferred embodiment, the specimen to be treated may be the circumferential edge surface of a circular silicon (Si) substrate having a diameter of, for example, around 2.0 millimetres and a length of around 1.0 millimetre and the roughness of the circumferential surface may be about 2 to 3 micrometers. The silicon substrate 101 to be treated may be fabricated using a DRIE process from a silicon wafer.

Before initiation of the laser treatment process, the specimen 101 may be cleaned using, for example, acetone (CH_3COCH_3), in an ultrasonic bath to remove any loose particles and residual masking material on the specimen 101.

After the cleaning process, the specimen 101 may then be dried and placed in between the first and second shafts 103 and 104 of the mounting device 100, as shown in Figure 2a. The guide 102, which is selected to be of a shape which will fit the particular specimen 101 to be used, may then be moved along the first shaft 103 to the specimen 101 to align the specimen on the axis about which it will rotate. The specimen 101 may be aligned in the slot of the guide 102 by manually rotating the second shaft 104, for example using a handle attached thereto, and adjusting the position of the specimen 101. Once alignment of the specimen 101 on the mounting device 100 has been completed, the guide 102 may be withdrawn back along the first shaft 103 and the specimen is ready then ready for laser treatment.

The third block 110 is not required for this embodiment and may therefore be removed.

Prior to commencing the laser treatment process, preferably the necessary software programs for controlling the motions and the parameters associated with the laser have been set, and the alignment of the mounting device 100 on the motion stage 200 has been completed.

In the embodiment where the motion stage 200 is used to achieve scanning, as shown in Figure 2a, possible settings for the laser treatment process of the aforementioned silicon substrate 101 may be as follows:

The rotating speed of motor 106 may be set to around 4000 RPM. The velocity of the motion stage 200 across the axial direction of the specimen component 101 may be set to around 0.1 mm/s. The power of the IR wavelength laser may be set to around 10 watts with a repetitive pulse rate of around 5 kHz.

The above settings may be denoted as Parameter A.

In an alternative embodiment, the motion stage 200 may be maintained stationary and a galvanometer 500 may be used for the scanning process. In this embodiment, possible settings for the laser treatment process of the aforementioned silicon substrate 101 may be as follows:

The rotating speed of the motor 106 may be set to around 600 RPM. The power of the IR wavelength laser may be set to around 100 watts with a repetitive pulse rate of around 5 kHz. The galvanometer scanning speed may be set to around 10 mm/s.

The above settings may be denoted as Parameter B.

The laser parameter settings and related alignment may be adjusted to enable the melting of the specimen's surface and to obtain optimum (smooth) finishing. The duration required for the laser treatment process is dependent on the laser

and motion parameter settings, specimen dimensions and the material from which the specimen 101 is formed. The duration of the laser treatment process may vary from a few milli-seconds to a few seconds.

During the treatment process, the laser beam may be approximately focused on the surface of the specimen 101 and need not be exactly at the focused point of the objective lens used for the laser source, which enables the treatment process to be performed without continual refocusing of the laser beam on the surface of the specimen 101. The laser treatment process of the fabricated micro-specimen is preferably performed at atmospheric pressure and at ambient temperature.

An extractor system (not shown) may be fitted to remove any undesired particles emitted from the surface of the specimen 101 during treatment. The extractor system may be a vacuum system for removing the undesired particles or material to prevent contamination on the surface of the specimen 101.

In the aforementioned embodiments, the circular silicon substrate 101 may be used as a spindle shaft for a micro-rotating mechanism. In such a mechanism, it has been found desirable to use a laser treated specimen 101 to reduce the roughness of the surface of the specimen. Further post-laser treatment processes may then be applied to the specimen 101, such as thin film coating, diamond-like carbon (DLC) coating, polymer coating and chemical processes to promote further reduction in the friction of the treated micro-components.

In a further preferred embodiment, the specimen to be treated may be, for example, the circumferential edge of a sleeve hole formed in a circular silicon substrate 101. The circular silicon substrate may have a diameter of around 10.0 millimeters and a thickness of around 1.0 millimetre, and the sleeve hole may have a diameter of around 3.0 millimeters. The specimen 101 may be fabricated by a DRIE process from a silicon wafer. The roughness of the sleeve hole surface may be about 2 to 3 micrometers. This form of specimen may be used as a rotor for a micro-rotating mechanism.

Before initiation of the laser treatment process, the specimen 101 may be cleaned using, for example, acetone (CH_3COCH_3), in an ultrasonic bath to remove any loose particles and residual masking material on the specimen 101. After the cleaning process, the specimen 101 is then dried and placed in the holder 105 of the mounting device 100 as shown in Figure 2c. The holder 105 may be specifically selected to be suitable for use with the particular specimen 101 to be treated.

As the position of the laser source unit 300 may be fixed in the mounting device 100, the goniometer on the motion stage 200 may be used to tilt the mounting device 100 at an angle such that the laser beam may cover and treat the entire sleeve hole surface of the specimen 101. When the alignment of the specimen 101 on the mounting device 100 has been completed, the specimen is then ready for the laser treatment.

Prior to commencing the laser treatment process, preferably the necessary software programs for controlling the motions and the parameters associated with the laser have been set, and the alignment of the mounting device 100 on the motion stage 200 has been completed.

In the embodiment where the motion stage 200 is used to achieve scanning, as shown in Figure 2c, possible settings for the laser treatment process of the aforementioned silicon substrate 101 may be as follows:

The rotating speed of motor 106 may be set to around 4000 RPM. The velocity of the motion stage 200 across the axial direction of the specimen component 101 may be set to around 0.1 mm/s. The power of the IR wavelength laser may be set to around 10 watts with a repetitive pulse rate of around 5 kHz.

The above settings may be denoted as Parameter A.

In an alternative embodiment, the motion stage 200 may be maintained stationary and a galvanometer 500 may be used for the scanning process. In

this embodiment, possible settings for the laser treatment process of the aforementioned silicon substrate 101 may be as follows:

The rotating speed of the motor 106 may be set to around 600 RPM. The power of the IR wavelength laser may be set to around 100 watts with a repetitive pulse rate of around 5 kHz. The galvanometer scanning speed may be set to around 10 mm/s.

The above settings may be denoted as Parameter B.

Again, the above comments with regard to optimizing the laser treatment process for the specimen apply similarly to these embodiments.

In a still further preferred embodiment, the specimen to be treated may be, for example, the stepped surfaces of a 2-step stainless steel (SUS) substrate. The 2-step stainless steel (SUS) substrate may have a length of around 5.0 millimeters, a width of around 2.0 millimeters and a height of around 0.5 millimeters for each step (giving a total height of around 1.0 millimetre). The specimen 101 may be fabricated by milling and grinding processes. The roughness of the stepped surface may be about 2 to 3 micrometers. This form of specimen may be used as a slider guide in a micro actuation mechanism.

Before initiation of the laser treatment process, the specimen 101 may be cleaned using, for example, acetone (CH_3COCH_3), in an ultrasonic bath to remove any loose particles and residual material on the specimen 101.

After the cleaning process, the specimen 101 may then be dried and placed on the third block 110 and in between the first and second shafts 103 and 104 of the mounting device 100, as shown in Figure 2a. As the surfaces of the SUS specimen to be treated in this embodiment are planar, no guide 102 is required for the process. When the alignment of the SUS substrate on the designed holding device 100 is completed, it is ready for the laser treatment.

Prior to commencing the laser treatment process, preferably the necessary software programs for controlling the motions and the parameters associated with the laser have been set, and the alignment of the mounting device 100 on the motion stage 200 has been completed.

For treating the planar surfaces of this SUS specimen 101, the X and Y motion of the motion stage 200 preferably has a linear scanning speed and interval steps so that the area to be scanned is covered uniformly. The motor on the motor mounting device 100 is preferably not required to rotate the mounting device in this embodiment.

In an alternative embodiment, the motion stage 200 may be maintained stationary and a galvanometer 500 may be used for the scanning process. Again, the above comments with regard to optimizing the laser treatment process for the specimen apply similarly to these embodiments.

The mounting device 100, when removed from motion stage 200, may be a useful tool for holding and rotating the specimen 101 when observing and measuring the surface roughness and roundness of the treated micro-components under measuring equipment such as a microscope and an optical profiler. Thus, the specimen 101 may be moved for further inspection after irradiation by the laser beam by transferring the mounting device 100 on which the specimen 101 is mounted to a further system for inspection.

After the laser treatment process of the specimens, the treated surfaces take a smooth appearance. The surfaces may be measured using a surface profiler, an optical profiler, a scanning electron microscope (SEM) or an atomic force microscope (AFM). In the above described preferred embodiments, the results of the measurements indicated that the surface roughness of the specimens were in the range of nanometer (nm) scale (~ 10 nm). For the above-described circular substrate, the roundness was also measured using optical profiler and measurement equipment. As the laser treatment only melts and improves the

surfaces of the substrate without significant deformation, the roundness and shape may be retained.

Also, while treating and improving the surfaces of the fabricated micro-components using the IR wavelength laser, small defect and debris may be covered up or eliminated during the laser treatment, whereas where there is a large defect, such as a crack or a fracture, the defect may be amplified or magnified. Amplification of the defect may easily be detected upon inspection, thereby enabling removal of such a defective component from usage.

As one or more preferred embodiments of the invention may be used for fabricated micro-components of varying designs and geometrical shape, additional elements may be added to the motion stage 200, as required. For mass production of a particular design and geometrical shape of specimen, only those elements necessary for providing motions in directions necessary for the treatment process of the particular specimen need be provided and the unnecessary elements of the motion stage 200 may be removed to reduce the cost and maintenance of the set-up. Furthermore, for mass production, the handling and holding of the fabricated micro-components on the mounting device may be automated to reduce the mishandling and contamination of the specimens.

As laser treatments of the fabricated micro-components according to one or more preferred embodiments of the invention may reduce the roughness of the surfaces of the specimens, the bonding or adhesion strength between the treated surfaces and the coated or applied materials may be enhanced. Thus, processes such as thin film coating, diamond-like carbon (DLC) coating, polymer coating or other chemical processes may be further applied as an additional improvement for the tribological performances of the treated micro-components.

Furthermore, the use of an IR wavelength laser enables heat to penetrate the component's surface causing it to melt and smooth its surface. Also, such an IR

wavelength laser may provide good repeatability of surface finish for the specimens.

One or more preferred embodiments of the invention may also enable the laser treatment to create a desired surface finishing on selected regions of fabricated micro-components for tribological performances, such as sliding and rotating.

Additionally, one or more preferred embodiments of the invention may enable the treatment process to be implemented on varying types of surface such as a planar surface, various circular surfaces (for example shaft, rod, ring, disk and plate), and other geometrically shaped surfaces (such as stepped, hexagonal and polygonal), as well as internal surfaces of thin planar and circular structured components (such as the internal sleeve surfaces of a ring, a disk or a plate).

Furthermore, the materials from which the specimens may be formed may be those used in semi-conductors (eg. silicon [Si], carbon), metals (eg. steel, aluminum), alloys (eg stainless steel), ceramics and polymers.. The fabrication processes used to make the specimens may include DRIE, grinding, milling, laser cutting or other conventional machining techniques.

The surfaces of the specimens fabricated using processes such as DRIE, grinding and laser cutting will have different types of finishing/roughness and one or more preferred embodiments of the invention may enable the use and control of the laser power, the repetition pulse rate and the scanning speed (when galvanometer is used) of the laser equipment to melt the specimen's surface and obtain optimum (smooth) finishing.

Furthermore, one or more preferred embodiments of the invention may enable the treatment of surface of the fabricated micro-components to be conducted under ambient conditions, that is, atmospheric pressure and room temperature.

In some treatments of fabricated micro-specimens, heat may also be introduced. The heat could be introduced to the micro-specimen for example by means of a

hot air blower. Introduction of heat for some specimens (eg. thick specimens formed of high thermal conductivity materials) may be beneficial in assisting the laser treated surface to flow and providing the smooth surface finishing. Also in some treatments of fabricated micro-specimens, gas may be introduced. Examples of gases which may be used are argon and nitrogen. The gas can be introduced onto the micro-specimen by means of a nozzle. Introduction of gas during laser treatment can help in providing a clean surface and also prevent oxidation of specimen's surface.

The fabricated micro-components are usually very small and the surface to be treated may be difficult to reach. Also, the surfaces to be treated may not be planar or flat (eg. circular). However, the mounting device may be fabricated for holding and guiding the fabricated micro-components to be treated.

As the fabricated micro-components may be used for tribological applications such as sliding and rotating motions, one or more preferred embodiments of the invention may enable the reduction of friction and thereby reduction of abrasion, heat and noise. Furthermore, the bonding and/or adhesion strength between the treated surfaces and the coated or applied materials may be enhanced.

Further processes such as thin film coating, diamond-like carbon (DLC) coating, polymer coating, or other chemical processes may be applied to the specimens after treatment and one or more preferred embodiments of the invention may enable a further reduction in friction in the tribological applications of the treated micro-components.

Various modifications to the embodiments of the present invention described above may be made. For example, other components and method steps can be added or substituted for those above. Thus, although the invention has been described above using particular embodiments, many variations are possible within the scope of the claims, as will be clear to the skilled reader, without departing from the spirit and scope of the invention.

Claims:

1. A method of treating a surface of a fabricated micro-specimen, the micro-specimen being in the form of a micro-component that is for sliding or rotating against another component, the method comprising irradiating said surface of said micro-component using an infrared (IR) wavelength laser to melt one or more asperities in said surface to smooth said surface, thereby improving the tribological performance of the micro-component.
2. A method according to claim 1, further comprising cleaning said surface prior to irradiating said surface.
3. A method according to claim 1, further comprising mounting said micro-component in a mounting device prior to irradiating said surface.
4. A method according to claim 1, further comprising selecting one or more operating conditions for said laser according to the shape of said micro-component and/or the material from which said micro-component is formed.
5. A method according to claim 1, further comprising rotating said micro-component during the step of irradiating.
6. A method according to claim 5, wherein the step of rotating said micro-component comprising rotating said micro-component using a motor.
7. A method according to claim 1, further comprising tilting said micro-component using a goniometer mounting during the step of irradiating.
8. A method according to claim 1, further comprising scanning said micro-component across a laser beam emitted from said laser during the step of irradiating.
9. A method according to claim 8, wherein the step of scanning said micro-component comprises moving said micro-component by moving a mounting device on which said micro-component is mounted.

10. A method according to claim 8, wherein the step of scanning said micro-component comprises deflecting said laser beam over said micro-component, said micro-component being maintained stationary.
11. A method according to claim 10, wherein the step of deflecting said laser beam comprises deflecting said beam using a galvanometer mirror.
12. A method according to claim 8, wherein the step of scanning said micro-component comprises deflecting said laser beam over said micro-component whilst moving said micro-component.
13. A method according to claim 5, wherein the step of rotating said micro-component comprises controlling rotation of said micro-component using a processor.
14. A method according to claim 7, wherein the step of tilting said micro-component comprises controlling tilting said micro-component using a processor.
15. A method according to claim 8, wherein the step of scanning said micro-component comprises controlling scanning of said micro-component using a processor.
16. A method according to claim 11, wherein the step of deflecting said beam comprises controlling movement of said mirror using a processor.
17. A method according to claim 1 wherein said step of irradiating said surface comprises irradiating an external surface of said micro-component.
18. A method according to claim 1 wherein said step of irradiating said surface comprises irradiating an internal surface of said micro-component.
19. A method according to claim 3, further comprising moving said micro-component for further inspection after the step of irradiating by transferring said mounting device on which said micro-component is mounted to a further system for inspection.

20. A system to treat a surface of a fabricated micro-specimen, the micro-specimen being in the form of a micro-component that is for sliding or rotating against another component, the system comprising a mounting device on which said micro-component to be treated is mountable, and an infrared (IR) wavelength laser for irradiating said surface of said micro-component, said laser being arranged to melt one or more asperities in said surface to smooth said surface, thereby improving the tribological performance of the micro-component.
21. A system according to claim 20, wherein said laser is arranged to operate according to the shape of said micro-component to be treated and/or the material from which said micro-component is formed.
22. A system according to claim 20, further comprising a rotating device for rotating said micro-component during irradiation thereof.
23. A system according to claim 22, wherein said rotating device comprises a motor.
24. A system according to claim 20, further comprising a tilting device for tilting said micro-component during irradiation thereof.
25. A system according to claim 24, wherein said tilting device comprises a goniometer mounting.
26. A system according to claim 20, wherein said mounting device is movable to permit scanning of said micro-component across a laser beam emitted from said laser during the step of irradiation of said micro-component.
27. A system according to claim 20, further comprising a deflector to deflect a beam emitted from said laser during irradiation of said micro-component to scan said micro-component, said micro-component being maintained stationary.

28. A system according to claim 27, wherein said deflector comprises a galvanometer mirror.

29. A system according to claim 20, further comprising a deflector to deflect a beam emitted from said laser during irradiation of said micro-component to scan said micro-component, said micro-component being movable during irradiation.

30. A system according to claim 22, further comprising a processor to control said rotating device.

31. A system according to claim 24, further comprising a processor to control said tilting device.

32. A system according to claim 26, further comprising a processor to control movement of said mounting device for scanning said micro-component.

33. A system according to claim 28, further comprising a processor to control movement of said mirror.

34. A system according to claim 20 wherein said laser is arranged to irradiate an external surface of said micro-component.

35. A system according to claim 20 wherein said laser is arranged to irradiate an internal surface of said micro-component.

36. A system according to claim 20, wherein said mounting device on which said micro-component is removable from said system for moving said micro-component for further inspection after irradiation by transferring said mounting device on which said micro-component is mounted to a further system for inspection.

37. A system according to claim 20, further comprising a guide for aligning said micro-component to be treated with said mounting device.

38. A system according to claim 37, wherein said guide is removable from said system prior to treatment of said micro-component.

39. A method of treating a surface of a fabricated micro-specimen, the micro-specimen being in the form of a micro-component that is for sliding or rotating against another component, the method comprising irradiating said surface of said micro-component using an infrared (IR) wavelength laser to melt one or more asperities in said surface causing said surface to flow thereby reducing the amount of surface irregularity, thereby improving the tribological performance of the micro-component.

40. A system to treat a surface of a fabricated micro-specimen, the micro-specimen being in the form of a micro-component that is for sliding or rotating against another component, the system comprising a mounting device on which said micro-component to be treated is mountable, and an infrared (IR) wavelength laser for irradiating said surface of said micro-component, said laser being arranged to melt one or more asperities in said surface causing said surface to flow thereby reducing the amount of surface irregularity, and thereby improving the tribological performance of the micro-component.