

## LASER MARKING METHOD

### TECHNICAL FIELD

5           The present invention relates to a laser processing method. In particular, it relates to a method for creating markings on a work piece by laser processing.

### BACKGROUND

10           Laser marking is a process of creating visually perceptible signs at pre-defined locations of a work piece using a laser beam. There are many types of lasers that can be used for marking in the industry, which includes CO2 laser, YAG laser, and diode lasers, etc. Apart from marking, a laser can also be used in micro-machining, surface processing, trimming, welding, and cutting, etc.

15           In a laser marking process, coordinate data or parameters of the locations on a work piece at which the marks are to be created, are programmed into a laser beam positioning controller, with reference to a coordinate system. In an ideal situation, work pieces are placed at a pre-defined theoretical position, i.e. in alignment with the coordinate system. The laser beam is then applied onto the  
20           work piece according to the programmed coordinate data, and marks can therefore be created at the pre-defined locations.

25           In an actual situation, however, a work piece is not usually placed in alignment with the coordinate system and/or the reference template. This may be due to the mechanical tolerance, the handling errors or positioning errors of placing the work piece. Therefore, in reality, a work piece is often placed in a laser marking system at a position which is shifted along a linear direction and/or a rotational direction, with respect to the pre-defined theoretical position. Without  
30           taking this linear and rotational shifting into consideration, marks will be created at undesired positions on the work piece, which is unacceptable. Accordingly,

positioning accuracy of a work piece under the laser beam becomes one of the key concerns to ensure the quality of laser marking.

Factors that can affect the positioning accuracy of a laser beam on a work piece include, for example, errors of the laser system and the optics that direct the laser beam onto the work piece, the handling, positioning and fixturing system and operation of the work piece, etc.

Previous systems have utilized measurement devices, such as measurement and position sensors, to detect and measure the offset between the actual position and the theoretical position of the work piece. A measurement result from the position sensor is sent to a controller of a handling system wherein the relative position between the laser beam and the work piece is adjusted so as to compensate the offset. As a separate measurement and position sensor is required, the system set up and operation is cumbersome, hence inefficient. The addition of the sensors can also be an additional source of system error.

US Patent 6,545,250 issued to Hartmann et al provides a method and apparatus for laser machining of work pieces. The apparatus according to this patent uses a light source as a reference to direct a light beam onto the surface of the work piece. The light reflected from the work piece is received by an optical detector, thereby a set-actual value comparison is carried out before the actual machining, and the actual position of a contour on the work piece can be determined.

In this and previous systems, the detected position of a contour or profile is considered to be the actual position at which a laser beam directed to process the work piece. In laser processing operations, however, a detected position is not always the same as the actual position because errors can also be introduced during the position detection due to, for example, the system errors of the measurement sensors or optics and/or the misalignment of the laser beam and light beam. The system errors can be significant for certain laser processing

applications, in particular those requiring a relatively high positioning accuracy, such as laser marking which generally requires a positioning error of about 0.1 mm or below. As the relationship between detected position and the actual marked position is unknown, the set-actual value comparison provided by US  
5 Patent 6,545,250 is not found suitable for laser marking operation that requires high positioning accuracy.

It is therefore desirable to provide a laser marking apparatus and system for creating markings at precise positions of a work piece, in which markings can  
10 be created on a work piece with high positioning accuracy, e.g. at an accuracy of about  $\pm 0.02$  mm.

## SUMMARY OF THE INVENTION

15 In accordance with one aspect of the present invention, there is provided a method for marking a work piece. The method comprises generating a wavelength compensating factor which represents an offset between the laser beam and the visible light beam caused by the differential in their wavelengths and a position compensating factor which represents the differential between the  
20 expected position of the work piece and its actual position as detected by a vision system. These compensating factors are used in deriving the marking coordinates used to direct the laser beam onto the work piece to create the mark at a high accuracy.

25 According to one embodiment of the present invention, the wavelength compensating factor is generated by creating a first calibration mark on the platform or a calibration template at a first point. The first calibration mark is created by directing a laser beam through a guiding optic assembly fixed at a first state. A first set of coordinate data is decoded by the guiding optic assembly.  
30 Subsequently, the guiding optic assembly is adjusted to a second state such that a visible light beam of the first calibration mark is received by a vision detector. A second set of coordinate data is decoded by the guiding optic assembly. A

difference of the first set and the second set of coordinate data is then obtained through which the wavelength compensating factor is determined. This compensating factor therefore compensates the error between the laser beam and the visible light beam resulting from their different wavelengths.

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According to a further embodiment of the present invention, two calibration marks are created. Through interpolation calculation, a compensating factor of a point along the line defined by the two calibration marks can be determined based on the compensating factors of the two calibration marks. The two calibration marks are selected such that the pre-defined marking location falls on the line defined by the two calibration marks. Three, four or more calibration marks may be created, defining a triangle, rectangle or polygon region, respectively, such that the region encloses the pre-defined marking location. Compensating factors of the three, four or more calibration marks can be used to calculate the compensating factor of a point or points overlapping the predefined marking location or locations through interpolation.

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As for deriving the position compensating factor, the work piece to be marked has two or more identification signs pre-made thereon. Locations on the work piece at which the mark is to be created, are pre-defined with respect to the two or more identification signs. An image of each identification sign of the work piece is detected by receiving a visible light beam through an f-Theta lens so as to determine a position of the work piece relative to a platform supporting the work piece. A set of marking coordinates is generated based on the position of the work piece and the pre-defined location. This set of marking coordinates therefore compensates for the error caused by mis-alignment of the work piece from its preset location, which is a common occurrences in operational processes.

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By incorporating the wavelength and position compensating factors into the originally designed marking parameters, revised marking coordinates can be obtained to direct the laser beam at positions according to the detected and/or calculated positions on the work piece.

In accordance with another aspect of the present invention, there is provided a method for marking a work piece supported on platform. The method comprises generating a compensating factor to represent an offset caused by a wavelength difference between a laser beam forming a calibration mark and a visible light beam detecting the calibration mark. A location on the work piece for marking is then defined using a first set of location identifiers. A position of the work piece relative to the platform is determined, and a second set of location identifiers is generated based on the first set of location identifiers, the position of the work piece and the compensating factor. A laser beam is directed onto the work piece to the second set of location identifiers to mark the work piece.

In accordance with a further aspect of the present invention, there is provided a method for marking work piece by laser, the method comprises loading a first work piece onto a platform; defining a location on the first work piece for marking using a first set of coordinates; detecting an image of the first work piece to determine a position of the first work piece relative to the platform; generating a compensating factor to reduce a positional difference between a first point on the first work piece at which a laser beam is directed and a second point from which a visible light beam is detected; generating a second set of coordinates based on the first set of coordinates, the position of the first work piece and the compensating factor; and directing a laser beam onto the first of the batch of work pieces at the second set of coordinates to mark the first work piece.

## **BRIEF DESCRIPTION OF THE DRAWINGS**

These and other aspects and advantages of the present invention will be described in detail with reference to the accompanying drawings, in which:

Fig. 1A is a schematic diagram showing a laser marking apparatus according to one embodiment of the present invention.

Fig. 1B is a schematic diagram showing a laser marking apparatus of Fig. 1A, and having a work piece placed thereon for marking.

5 Fig. 2A is a schematic diagram showing a laser beam directed onto a work piece for marking, and a visible light reflected from the work piece for vision detection.

10 Fig. 2B is a schematic diagram showing compensation of a laser beam and a visible beam of Fig. 2A.

15 Figs 3A and 3B show possible situations of difference between a detected mark as compared to that actually marked.

20 Fig. 4A is a schematic diagram showing distinctive features marked for determining the error between marking and detection.

Fig. 4B is a schematic diagram showing features at detected position.

25 Fig. 5A is a schematic diagram showing compensating factor determination using two calibration marks.

Fig. 5B is a schematic diagram showing compensating factor determination using four calibration marks.

30 Fig. 5C is a schematic diagram showing compensating factor determination using three calibration marks.

Fig. 6A is a schematic diagram showing features that the vision detector is taught to register a standard reference position.

Fig. 6B is a schematic diagram showing same features on a work piece for detection and comparison with the standard reference position.

Fig. 7 is a schematic diagram showing a further embodiment of the present invention, in which a group of work pieces are placed on the laser system for marking.

Fig. 8 is a flow chart showing a laser marking method according to the present invention.

### DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

Fig. 1A shows a laser marking apparatus 100 for marking a work piece according to one embodiment of the present invention. Fig 1B shows the apparatus of Fig. 1A and having a work piece placed thereon for marking. According to Figs. 1A and 1B, the apparatus 100 comprises a laser source 110, such as a YAG laser or a CO<sub>2</sub> laser, for providing a laser beam 112 with an energy level sufficient to create a mark on a work piece. A first mirror 120 deflects laser beam 112 to a second mirror 130. Second mirror 130 further deflects laser beam 112 to a guiding optic assembly, such as a scan head 140. Two galvo-controlled mirrors 142 and 144 are provided in scan head 140 for receiving and further directing laser beam 112 onto a platform 150. Platform 150 is provided to support a work piece 200 thereon for laser marking. Galvo mirrors 142 and 144 are axially aligned in an orthogonal arrangement. Each galvo mirror is independently mounted on a corresponding pivotal axis. Scan head 140 having two galvo mirrors 142 and 144 arranged in the above manner is capable of deflecting, directing and steering laser beam 112 along an X direction and a Y direction, respectively, so that laser beam 112 can reach any position within the two-dimensional environment of platform 150.

The apparatus 100 has a vision detector 160, such as a CCD camera, for receiving and detecting visible light beam 212 from platform 150 and/or work piece 200. Vision detector 160 is placed behind second mirror 130. Second

mirror 130 is a dichroic mirror which reflects the laser beam and allows the visible light to pass through.

5 A convergent lens 170 is provided between scan head 140 and platform 150. In this embodiment, convergent lens 170 is an f-Theta lens. F-Theta lens 170 focuses laser beam 112 onto work piece 200. Visible light beam 212 also passes through f-theta lens 170 and can be directed back through galvo mirrors 142, 144 and second mirror 130, into vision detector 160. An "f-Theta lens" is a convergent lens which maintains the focusing of a laser and/or light beam on a plane when the incident angle of the laser and/or light beam varies. The incident angle and the moving distance of the laser and/or light beam on the plane follow a linear relationship. In one embodiment, the f-Theta lens is a color-corrected scan lens capable of allowing two or more laser and/or light beam with difference wavelengths to pass through while maintaining the focuses for both light beams on the same plane.

10 Vision detector 160 is positioned with its optical axis 162 in alignment with a path of laser beam 112 between galvo mirror 142 and second mirror 130. By this arrangement, visible light 212 from work piece 200 or platform 150 travels along a same path as the laser beam 112, between second mirror 130 and f-Theta lens 170. Accordingly, galvo-mirrors 142 and 144 also serve the function to determine a coordinate data to direct laser beam 112 onto the platform 150 or work piece 200, and to decode a coordinate data of visible light beam 212 received by vision detector 160.

25 A controller 180 is coupled to scan head 140 and vision detector 160. A processor 190 is coupled to controller 180. Controller 180 controls the pivoting of galvo mirrors 142, 144 so that to deflect laser beam 112 onto platform 150 and direct visible light beam 212 back to vision detector 160. Controller 180 also determines position coordinates of a first point P1 at which laser beam 112 is directed, and a second point P2 from which an image is detected by vision detector 160. Processor 190 calculates the difference of the position coordinates

of the first point and the second point, so that to determine a compensation factor to reduce or eliminate the positional difference between the first point P1 and the second point P1.

5           According to the present invention, the positional relationship of laser beam 112 directed to work piece and visible light beam 212 reflected from work piece can be quantitatively determined. For the purpose of determining the positional relationship of the laser beam 112 and the visual light beam 212, platform 150 is used as a calibration template. Alternatively, a calibration template 152 may be  
10           provided on platform 150.

Fig. 2A is a schematic diagram showing a laser beam directed onto a work piece for marking, as well as a visible light beam reflected from the work piece for vision detection. Following the illustration of Figs. 1A and 1B, with like reference  
15           numerals referring to like elements, laser beam 112, deflected by galvo mirrors 142, 144 and focused by f-Theta lens 170, is directed onto work piece 200 for marking. As laser and visible light have different wavelengths, when galvo-mirrors 142 and 144 are fixed at one specific position or state, which corresponds to a specific set of coordinate data, there exists a positional difference or offset  
20           between a first point P1 at which laser beam 112 is applied onto work piece 200, and a second point P2 from which visible light beam 212 is reflected from work piece 200. As such, one specific set of coordinate data determined by galvo mirrors 142 and 144 represents the position of P1 for laser beam 112, and P2 for visible light beam 212. Following this illustration, one would appreciate that when  
25           the marking process is carried out in the two-dimensional environment of the whole area of the work piece 200, without proper adjustment of galvo mirrors 142 and 144, the position of a mark created by the laser beam can be different from what is detected by the vision detector, i.e. there exists an offset between a position detected for marking, and a position actually marked.

Upon identification of the existence of the offset, the present invention further provides an effective solution to compensate the offset, as illustrated in detail below, in conjunction with Fig. 2B.

5 As shown Fig. 2B, in order to determine the offset value, the pivotal angle of galvo mirrors 142 and 144 are adjusted from a first state, represented by 142a and 144a respectively, to a second state, represented by 144a and 144b, respectively upon which point P2 is brought to overlap point P1. As mentioned above, the pivotal angles of galvo mirrors 142 and 144 corresponding to the first and the second states are decoded by controller 180, whereby coordinate data  
10 can be obtained corresponding to each state. Comparing the coordinate data decoded for each state, the offset value can be quantitatively determined and defined as a compensating factor to reduce or eliminate the positional difference between P1 and P2.

15 A calibration operation can be performed accordingly, as shown in Fig. 2B. In a first step, galvo mirrors 142 and 144 are fixed at a first state 142a and 144a, respectively. Laser beam 112 is directed through galvo mirrors 142, 144 and f-Theta lens 170 onto first point P1 of work piece 200 or calibration template 152. Controller 180 decodes and records a first set of position coordinates correspond  
20 to the first state. In a next step, galvo mirrors 142 and 144 are adjusted to a second state 142b and 144b, respectively, such that visible light beam at point P1 is detected by vision detector 160. By adjusting galvo mirrors 142 and 144 from the first state to the second state, P2 is brought to overlap P1. Controller 180 then decodes and records a second set of position coordinates correspond to the  
25 second state. Difference value between the first set and second set of position coordinates is calculated by processor 190, as a compensating factor to reduce or eliminate the error between a detected position and a marked position.

30 According to one embodiment of the present invention, the compensating factor is determined by a first party, who supplies a laser marking system or calibrates the laser marking system. A second party, who is the user of the laser

marking system to perform marking operations, receives the compensating factor of the laser marking system and uses the compensating factor, together with predetermined design data, to generate marking coordinates or marking data to perform the marking.

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According to another embodiment of the present invention, the determination of the compensating factor can be carried out at the user side based on the predetermined marking positions, prior to the marking operation. The compensating factor can then be used, together with predetermined design data, to generate marking coordinates or marking data to perform the marking.

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It should be appreciated according to the above illustration, that with the change of the galvo-mirror pivotal angle, the laser beam will be directed onto the work piece or calibration template at different points. The offset or error value changes according to the position of the points. In an actual marking operation, if a mark is to be created based on only one predetermined location, a compensating factor can be generated for this location. If a mark is to be created based on two predetermined locations, compensating factors for each one of the two predetermined locations may need to be generated. Alternatively, the compensating factor of each predetermined location may be obtained by interpolation through points located along a line connecting the one or two predetermined locations. In the event that three or more predetermined locations are based on to create a mark, the compensating factor for each of the three or more predetermined locations can be generated by interpolation through points defining a triangle, rectangle or polygon region enclosing all the three or more predetermined locations. Details of generating compensating factors under each of the above situations are illustrated below.

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Figs 3A and 3B show possible situations that a vision-detected contour 312 and 314 (shown in dashed line), according to the coordinate data decoded by the galvo-mirrors, can be different from a respective actual marked contour 322 and 324, 326 (shown in solid line). In Fig. 3A, vision-detected contour 312 is smaller

than actual marked contour 322. In Fig. 3B, vision-detected contour 314 is larger than actual marked contour 324.

To determine the error of a detected position relative to a marked position, firstly, as shown in Fig. 4A, distinctive features, such as four small circles 402, 404, 406 and 408 are marked each at one corner of platform 150 or calibration template 152, for example, at points a(10, 10), b(100, 10), c(10, 100) and d(100, 100), respectively. As illustrated above, coordinates of points a, b, c and d are controlled by galvo-mirrors fixed at a first state. By adjusting the galvo-mirrors to a second state, vision detector 160 receives light beam reflected from small circles 402, 404, 406 and 408, respectively. Because of the misalignment between laser beam and light beam, positions of the four circles detected have offset from the respective position actually marked, for example, at a'(9.8, 9.8), b'(100.2, 9.8), c'(9.8, 100.2) and d'(100.2, 100.2), respectively, as shown in Fig. 4B. Positional errors Ea, Eb, Ec and Ed of each circle along X and Y direction can then be determined by comparing the above two groups of coordinate data.

Reference is now made to Fig. 5A. A schematic diagram illustrating the error calculation of a position between two reference points is shown, in which Ea and Eb denotes errors at two reference points 502 and 504, respectively. En denotes the error at a selected position n between points 502 and 504. Position n corresponds to a predetermined location 550 at which a mark is to be created. En can therefore be obtained by the following formula:

$$E_n = E_a + (E_b - E_a) * a/b \quad (1)$$

where

a is the distance between point 502 and point n; and  
b is the distance between point 502 and point 504.

In the above embodiment, the two reference points are arranged to cross a location 550 at which a mark is to be created on a work piece. Preferably, position n is selected to overlap location 550.

5 Similarly, according to another embodiment of the present invention and further referring to Fig. 5B, error  $E_m$  of a point m between two reference points 506 and 508 can also be calculated by the following formula:

$$E_m = E_c + (E_d - E_c) * c/d \quad (2)$$

10 Further, the error of any point within the rectangle region defined by reference points 502, 504, 506 and 508 on the platform,  $E_o$ , can be calculated as:

$$E_x = E_n + (E_m - E_n) * x/n \quad (3)$$

15 In this embodiment, the rectangle region is arranged to enclose a location 560 at which a mark is to be created on a work piece. Preferably, position x is selected to overlap location 560.

20 According to an alternative embodiment of the present invention, three reference points 502, 504 and 506 are provided and forming a triangle region over the platform, as shown in Fig. 5C. With like reference signs denoting like features, an error  $E_o$  at a point O within the triangle region can be determined as follows:

$$\begin{aligned} E_x &= E_c + (E_n - E_c) * x/n \\ &= E_c + \{ [ E_a + (E_b - E_a) * a/b ] - E_c \} * x/n \end{aligned} \quad (4)$$

25 In this embodiment, the triangle region is arranged to enclose a location 570 at which a mark is to be created on a work piece. Preferably, position x is selected to overlap location 570.

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By introducing the error or offset value of each programmed points into the original coordinates, the error between the vision light and the laser beam can be compensated. A system according to the present invention, after the above compensation operation, is now capable of performing vision detection to  
5 measure the actual position of the work piece, so that to create marks at accurate, predetermined position.

In actual marking process, another factor that may contribute to marking at undesired position of a work piece is that the work piece may be misaligned  
10 during handling and fixturing. With the successful compensation of initial errors between the laser beam and visible light, a laser marking system and method according to the present invention provide a reliable solution to detect the actual position of a work piece, so that to compensate the error caused by misalignment of the work piece.

As shown in Fig. 6A, after the compensation of errors or offsets between the laser beam and visible light beam illustrated above and prior to the actual marking process, a reference template 600 is placed on the platform 650.  
Reference template 600 has at least two distinctive features 612 and 614 provided  
20 at known positions, for example, at positions (15, 15) and (60, 60). Through vision detection, the apparatus is taught to recognize and register the shape/profile and the position of distinctive features 612 and 614.

As shown in Fig. 6B, when a work piece 200 is placed on platform 650 for  
25 marking, the vision detector will search through the two dimensional area of work piece 200, for features which match the shape/profile of features 612 and 614 learnt in the previous step. By way of example only, features 622 and 624 on work piece 200 are recognized to match the shape or profile of reference features 612 and 614, respectively. Due to the shifting and rotating of work piece 200, the  
30 position of feature 622 is detected as (15.2, 15.2) and the position of feature 624 is detected as (59.5, 60.9).

By comparing to the registered positions (15, 15) and (60, 60), the linear shifting and angular shifting of work piece 200 with respect to the reference template 600 can be determined. Error values calculated thereof can then be introduced into the designed marking coordinates with reference to the reference template, so that the shifting and/or rotating of work piece 200 is compensated. During actual marking, the mark can be created at desired correct position on the shifted work piece. Accordingly, when a work piece is misaligned, the system is capable of compensating the shifting and creating the mark at correct position.

When a next work piece is placed on the platform for marking, the same feature-searching step is repeated prior to marking, so that the shifting and rotating of the present work piece can be determined, and markings can be created at corrected positions.

According to a further embodiment of the present invention, a batch of work pieces, such as semiconductor IC chips moulded together on a lead frame, are to be marked. These work pieces are placed on platform 750 in an array manner, as shown in Fig. 7.

In this embodiment, each work piece has visually detectable features pre-made thereon during the manufacturing process. The size, shape and position of the visually detectable features are the same on each work piece, which are used as positioning reference for marking the work piece. A first work piece 702 has two reference circles or dots 702a and 702b as the positioning reference, each located at one corner of the work piece. First work piece 702 is placed on platform 750 at an accurate location, and is used as reference template. The information pertaining to the size, shape and position of reference dots 702a and 702b are detected and registered by the laser marking apparatus.

When a next work piece is desired to mark, e.g. work piece 704, the laser marking apparatus detects reference dots 704a and 704b pre-made on work piece 704. Result of the detection is then compared with the registered information so

that the linear and/or rotational shift of work piece 704 is determined. By introducing the linear and/or rotational shift value into the pre-programmed marking data or parameters, actual position of work piece at which a mark is to be created, can be determined. A laser beam is directed onto work piece 704 accordingly to the actual position of work piece 704, so that to mark the work piece 704 at corrected location.

Same registration, comparison and determining process are repeated for each of the subsequent work pieces 706, 708, etc. accordingly so that marks can be created at each subsequent work piece at corrected location.

Reference is now made to Fig. 8. A method 800 for marking a work piece on a platform for marking is provided. Each of the work pieces to be marked according to the present invention has at least two identification signs pre-made thereon. In a first block 802, a template with calibrating marks are used through which a wavelength compensating factor is generated, which represents an offset between the laser beam and the visible light beam caused by the wavelength difference. In a second block 804, the identification signs on the work piece placed on the platform is detected by receiving a visible light beam of the identification signs through an f-theta lens to determine a position of the work piece relative to the platform. The differential in positions of the work piece from its predefined location is used to derived the position compensation factor. In a next block 806, the newly derived set of marking coordinates is generated based on the pre-defined location, the actual position of the work piece and the wavelength and position compensating factors. These compensating factors are used to reduce the positional difference between a first point on the platform or work piece at which a laser beam is directed and a second point from which a visible image is detected. In a subsequent block 808, a laser beam is directed onto the work piece at the derived set of marking coordinates so as to mark the work piece at the desired, precise location.

Although embodiments of the present invention have been illustrated in conjunction with the accompanying drawings and described in the foregoing detailed description, it should be appreciated that the invention is not limited to the embodiments disclosed, and is capable of numerous rearrangements, enhancements, modifications, alternatives and substitutions without departing from the spirit of the invention as set forth and recited by the following claims.

## CLAIMS

1. A method for marking a work piece by a laser beam at a pre-defined location, the work piece being supported on a platform and having at least two identification signs, the method comprising:
  - generating a wavelength compensating factor, wherein the wavelength compensating factor represents an offset between a laser beam and a visible light beam caused by a wavelength difference thereof;
  - detecting a visible light beam of each of the two identification signs through an f-theta lens to determine a position of the work piece relative to the platform to derive a position compensating factor;
  - generating a set of marking coordinates based on the pre-defined location, the position of the work piece, the wavelength compensating factor and the position compensating factor, and
  - directing a laser beam onto the work piece at the set of marking coordinates to mark the work piece.
2. The method as recited in claim 1, wherein generating the wavelength compensating factor further comprises:
  - directing a laser beam through a guiding optic assembly at a first state onto a calibration template to form a first calibration mark, wherein the first state corresponds to a first set of coordinates;
  - detecting a visible light beam of the first calibration mark through the guiding optic assembly at a second state, wherein the second state corresponds to a second set of coordinates; and
  - determining a coordinate difference between the first set and the second set of coordinates;wherein the wavelength compensation factor is generated based on the coordinate difference.
3. The method as recited in claim 2, wherein the first calibration mark overlaps the pre-defined location for marking the work piece.

4. The method as recited in claim 2, further comprising:  
forming a second calibration mark, wherein the first and second  
calibration marks define a line across the pre-defined location, and  
5 determining a second compensating factor for the second calibration  
mark,  
wherein the wavelength compensating factor is generated based on the  
first and second compensating factors.
- 10 5. The method as recited in claim 4, further comprising:  
forming a third calibration mark, wherein the first, second and third  
calibration marks define a triangle region enclosing the pre-defined  
location, and  
determining a third compensating factor for the third calibration mark,  
15 wherein the wavelength compensating factor is generated based on the  
first, second and third compensating factors.
6. The method as recited in claim 5, further comprising:  
forming a fourth calibration mark, wherein the first, second, third the  
20 fourth calibration marks define a rectangle region enclosing the pre-  
defined location, and  
determining a fourth compensation factor for the fourth calibration mark,  
wherein the wavelength compensating factor is generated based on the  
first, second, third and fourth compensating factors.
- 25 7. The method as recited in claim 1, further comprising:  
providing a reference template having at least two position locators,  
wherein each position locator corresponds to an identification sign  
on the work piece;  
30 detecting a visible light beam of each of the at least two position  
locators on the reference template;  
registering a position for each of the at least two position locators,

detecting a visible light beam of each of the two identification signs on  
the work piece;  
wherein the position compensating factor of the work piece is  
determined by matching each of the detected identification sign to a  
corresponding position locator.

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8. The method as recited in claim 7, further comprising:  
loading at least two work pieces on the platform at a same time,  
determining a first position of a first work piece of the at least two work  
10 pieces;  
marking the first work piece;  
determining a second position of a second work piece of the at least two  
work pieces;  
marking the second work piece; and  
15 unloading the at least two work pieces.
9. A method for marking a work piece by laser, the work piece being  
supported on a platform, the method comprising:  
generating a compensating factor to represent an offset caused by a  
20 wavelength difference between a laser beam forming a calibration  
mark and a visible light beam detecting the calibration mark;  
defining a location on the work piece for marking using a first set of  
location identifiers;  
determining a position of the work piece relative to the platform;  
25 generating a second set of location identifiers based on the first set of  
location identifiers, the position of the work piece and the  
compensating factor; and  
directing a laser beam onto the work piece to the second set of location  
30 identifiers to mark the work piece.
10. The method as recited in claim 9, wherein generating the compensating  
factor further comprises:

directing a laser beam through a guiding optic assembly at a first state  
onto a calibration template to form a calibration mark, wherein the  
first state corresponds to a first set of coordinates;

5 detecting a visible light beam of the first calibration mark through the  
guiding optic assembly at a second state, wherein the second state  
corresponds to a second set of coordinates; and

determining a difference between the first set and the second set of  
coordinates to determine the compensating factor.

10 11. The method as recited in claim 9, wherein determining the position of the  
work piece comprising:

providing a reference template having at least two position locators,  
detecting a visible image of each of the at least two position locators;  
registering a position of each of the at least two position locator,

15 detecting an image of at least two identification signs provided on the  
work piece;

matching the image of each of the identification sign to a corresponding  
position locator to determine a position of the work piece relative to  
the reference template.

20 12. A method for marking work pieces by laser, the method comprising:

generating a compensating factor to reduce a positional difference  
between a first point on the first work piece at which a laser beam is  
directed and a second point from which a visible light beam is  
25 detected;

loading a first work piece onto a platform;

defining a location on the first work piece for marking using a first set of  
coordinates;

30 detecting an image of the first work piece to determine a position of the  
first work piece relative to the platform;

generating a second set of coordinates based on the first set of  
coordinates, the position of the first work piece and the  
compensating factor; and  
directing a laser beam onto the first of the batch of work pieces at the  
second set of coordinates to mark the first work piece.

13. The method as recited in claim 12, wherein generating the compensating factor further comprises:

directing a laser beam through a guiding optic assembly at a first state  
onto a calibration template to form a calibration mark, wherein the  
first state corresponds to a first set of coordinates;

detecting a visible light beam of the first calibration mark through the  
guiding optic assembly at a second state, wherein the second state  
corresponds to a second set of coordinates; and

determining a difference between the first set and the second set of  
coordinates to determine the compensating factor.

14. The method as recited in claim 12, further comprising:

loading at least one subsequent work piece onto the platform together  
with the first work piece;

determining a first position of a first work piece;

marking the first work piece;

determining a second position of the at least one subsequent work  
piece, and

marking the at least one subsequent work piece.