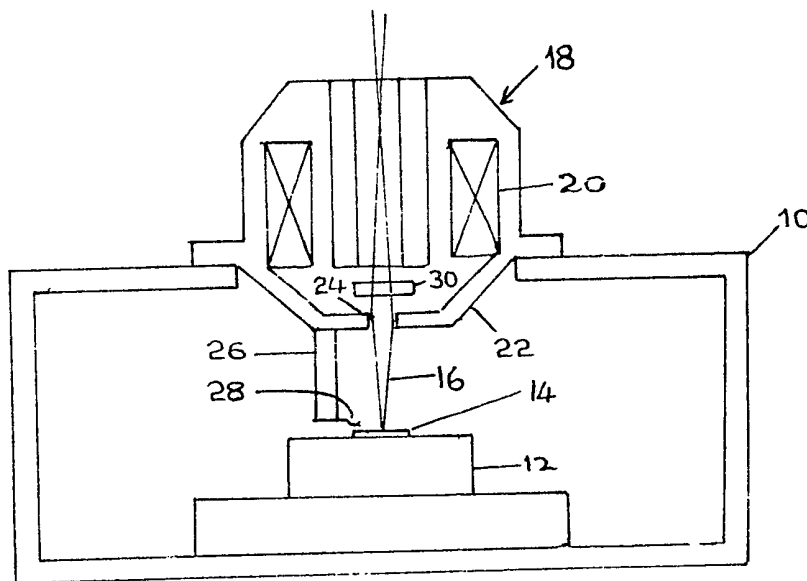


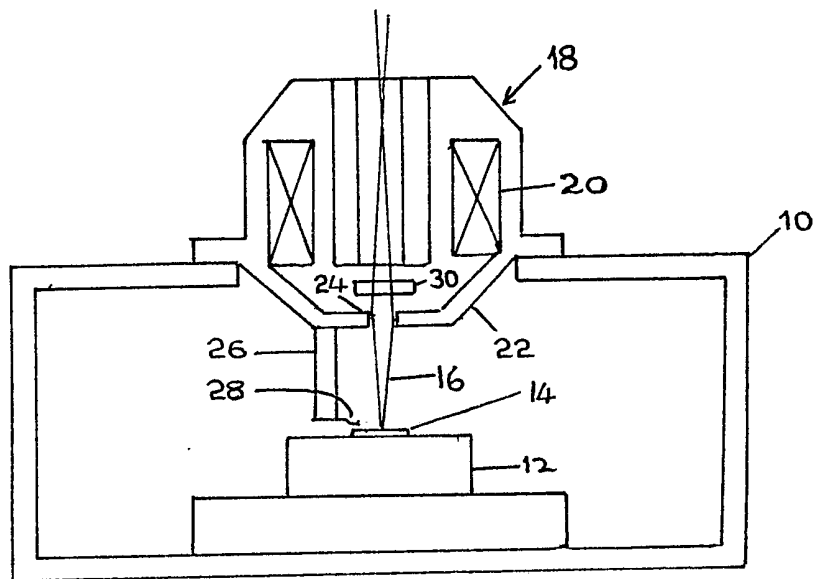
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(54) **Improvements in electron beam scanning devices**

(57) An arm (26) extends from the final lens assembly (18) of an electron beam column, and supports a probe (28) which protrudes into the area of scanning of the beam (16) just above the plane in which the beam is normally focussed, and which carries an index mark. A memory stores correction signals which have to be applied to the deflecting coils to obtain correct registration of the beam on the index mark. These correction signals are then applied during subsequent deflections of the beam.



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SPECIFICATION

Improvements in electron beam scanning devices

5 *Field of invention*

This invention concerns electron beam scanning devices and in particular an improved method and device for determining whether beam drift has occurred to allow appropriate correction to be made.

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Background to the invention

In many electron beam scanning systems it is necessary to be able to accurately deflect the beam to a high order of accuracy from one position to another. One example of such a system is an electron beam microfabrication apparatus where the beam is used to expose fine line patterns (of the order of 0.2-5µm wide) on a resist covered substrate. After exposure and development the patterns so

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formed can be used as selective window areas for chemical or ionic etching and as evaporated metal masks useful in the fabrication process of a wide range of micro devices, semiconductors, etc.

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One of the problems associated with such apparatus is that whilst a given beam deflection current will produce a deflection of a given amount in a given direction at one point in time, it is found in practice that due to various factors, the same beam deflection current may produce a different amount

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of deflection of the beam at a later point in time. The error may be very small and for non-microscopic work can usually be accommodated without correction. However for accurate work at the microscopic levels indicated above, correction techniques have

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to be incorporated into such apparatus so that any changes in the electron beam deflection system which produce a change in the operational function of the deflection system on the beam can be detected and corrected. In the event that no drift or

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change occurs, the deflection of the electron beam will always be the same for a given beam deflection current and since changes will produce a different deflection of the beam for the same current so that the beam will impinge on a different point which

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does not register with the first point, the degree of alignment of the beam with the position it should adopt is referred to as the beam registration.

Prior art

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Techniques for checking and correcting the registration of an electron beam have been proposed. In one method index marks are formed on the substrate before the latter is inserted into the apparatus and the beam is deflected so as to register with the marks before the start of the scanning pattern. The position of the marks is determined by detecting the change in contrast as the beam intersects the marks. A disadvantage of this method is that the stage on which the substrate is mounted will usually have to

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be moved so as to present the region containing the index marks below the beam and another disadvantage lies in the need to provide the marks at each exposure location on the substrate.

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An alternative method which has been proposed is

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system using for example a laser interferometer and to register the beam with respect to it and a unique mark located on the stage or substrate. This alternative method still requires the mark to be provided

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and invariably will require XY movement of the stage to locate the mark for the registration check to be performed. Furthermore there is always the possibility in both known methods that drift will occur after the registration of the beam has been checked and corrected and before the next check.

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Whilst this disadvantage is common to all systems which do not continuously monitor the registration of a beam (assuming that was possible) the tendency is that in known methods, the check on registration is only made as infrequently as possible because of the time required to relocate the stage and/or substrate to allow the check to be made.

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Object of the invention

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It is an object of the present invention to provide an improved method and device for allowing electron beam registration to be checked with minimal delay in the overall operation of the apparatus incorporating the electron beam so that a greater

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number of checks can be made during the scanning process thereby improving the accuracy of the equipment or the total time required to perform a given scanning process can be reduced for the same level of accuracy obtainable for a given number of

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registration checks.

The invention

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According to the present invention a device for indicating the registration of an electron beam comprises an index mark carried by an arm which extends from and is secured to the final lens

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assembly of the electron beam forming the system, the length of the arm being such that the mark is located just above the surface on which the electron beam is normally focused and the position of the mark is such as to be at a convenient point within the area in which the beam can be deflected.

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According therefore to another aspect of the present invention a method of checking the registration of an electron beam comprises subjecting the beam to a given deflection current which should cause the beam to align accurately with an index mark carried by an arm fixed to and protruding from the final electron lens assembly, making corrections

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to the deflection current if the said given current does not cause the beam to accurately register with the said index mark until the correct registration of the beam and mark is obtained, storing said corrections and applying the same corrections to subsequent deflection currents supplied to cause the

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beam to be deflected to one or more desired locations and subsequently deflecting the electron beam using said given deflection current modified by the previous corrections applied and performing the correction process once again to update the corrections required to the deflection currents for subsequent deflections to one or more desired locations.

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It will be seen that by using the device and method

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according to the invention, the checking and correct-

ing process can be carried out very quickly without having recourse to moving the stage or the substrate by simply applying a given deflection current to the electron beam deflecting unit and making the necessary corrections to that current before continuing with the exposure or scanning process which entails subsequent accurate deflections of the electron beam to precise locations on the surface which is being scanned.

10 A further advantage deriving from the invention is that no marks need to be applied to the surface which is being scanned nor to the stage.

A further advantage is that if necessary the registration check can be performed after every exposure deflection of the electron beam in for example a microfabrication exposure process so that the beam is returned to the deflected position in which it impinges on the index mark provided by the invention after every deflection, the position at which it impinges on the index mark being referred to as the home position of the beam.

To counteract deflection errors due to non-uniformity of the deflection producing unit, two or more index marks may be provided in accordance with the invention on extensions from the said protruding arm or from other protruding arms and the beam is deflected first to one and then another of said index marks and corrections made at each point in accordance with the method outlined above. In such an arrangement the number of stores required for storing the homing deflection current and subsequent corrections thereto would be determined by the number of index marks provided.

The invention will now be described by way of example with reference to the accompanying drawing which is a cross-sectional side view through the vacuum chamber of beam scanning apparatus embodying the invention.

40 *Detailed description of the drawing*

As shown in the drawing within a vacuum chamber 10 is mounted a stage generally designated 12 capable of performing X and Y movements and adapted for movement in a perpendicular Z direction for focusing. The drive means for the stage 12 is not shown.

Mounted on the stage is a substrate 14 and focused onto the surface of the substrate 14 is a beam of electrons generally designated 16 which is formed by and deflected in conventional manner by an electron gun assembly generally designated 18 having a final lens 20.

The final lens is contained within a housing generally designated 22 having an aperture 24 through which the beam 16 can pass. The housing of the lens is in known manner sealed to the vacuum chamber 10 and provides a mounting for an arm or peg 26 which depends therefrom towards the surface of the substrate 14. At the lower end of the arm 26 is a horizontal probe 28 bearing a feature or index mark onto which the beam 16 can be focused when appropriately deflected.

Although not shown the substrate and/or stage 12 include index marks for initial registration and at the beginning of an exposure process registration of the

beam 16 to both stage and substrate would be checked using the appropriate index marks on the stage and substrate and the index mark (not shown) on the probe 28.

70 After initial registration of the stage and substrate no further check is needed with regard to these items assuming that the tolerances in the stage movement are acceptable.

A check on drift and so-called beam wander can be made subsequently by simply deflecting the electron beam 16 onto the index mark on the probe 28 and checking the currents required to cause the beam to impinge precisely on the mark. The corrections required to cause the beam to impinge accurately on the mark are then used to correct subsequent beam deflection currents as applied to the beam deflection unit until the next check on beam registration.

It will be appreciated that the index mark on the probe 28 cannot be precisely in the same focal plane as the substrate surface and therefore the beam 16 will not be correctly focused for the index mark. To this end a dynamic refocusing system is provided (not shown) which adjusts the focus of the beam automatically when the homing deflection current is applied to the deflection unit to cause the beam to home on the index mark on the probe 28. The refocusing is fixed to ensure that the beam is correctly focused at the new focal plane. A typical dynamic refocusing coil 30 may be situated in the lens as shown in the drawing. The coil is typically driven by a signal proportional ($X^2 \times Y^2$) where X and Y are the deflection signals in the X and Y directions.

It is appreciated that although this may produce additional beam shifts these should be constant and will not affect overall registration during the check on the mark. Furthermore the relatively high depth of focus and spherical image field of the final lens will both tend to overcome the non-par-focal conditions.

CLAIMS

1. A device for indicating the registration of an electron beam comprising an index mark carried by an arm which extends from and is secured to the final lens assembly of the electron beam forming the system, the length of the arm being such that the mark is located just above the surface on which the electron beam is normally focused and the position of the mark being such as to be at a convenient point within the area in which the beam can be deflected.

2. A device as claimed in claim 1 in which there are a plurality of arms which extend from the final lens assembly and each carries an index mark.

3. A device as claimed in claim 1 in which a plurality of index marks are provided on extensions from the said protruding arm.

4. A method of checking the registration of an electron beam comprising the steps of:
subjecting the beam to a given deflection current which should cause the beam to align accurately with an index mark carried by an arm fixed to and protruding from the final electron lens assembly, making corrections to the deflection current if the

said given current does not cause the beam to accurately register with the said index mark until the correct registration of the beam and mark is obtained, storing said corrections in a memory, and

5 reading the memory during subsequent scanning and applying the same corrections to subsequent beam deflection currents and deflecting the electron beam using the modified deflection currents.

10 5. A method as claimed in claim 4 comprising the steps of performing the correction process and entering revised corrections in the memory for applying to deflection currents for subsequent deflection of the beam.

15 6. A method as claimed in claim 4 in which the registration check is performed after every exposure deflection of the electron beam in a microfabrication exposure process by returning the beam to the deflected position in which it impinges on the index mark after every exposure deflection, the position at
20 which it impinges on the index mark being referred to as the home position of the beam.

7. A method as claimed in any of claims 4 to 6 in which the beam is deflected first to one and then another of a plurality of index marks and corrections
25 are made at each point and correction information is stored in a memory for each index mark.

8. A method as claimed in claim 7 in which a different memory is provided for each index mark.

30 9. A device as claimed in claim 1 constructed, arranged and adapted to operate substantially as herein described with reference to and as illustrated in the accompanying drawing.

10. A method as claimed in claim 4 substantially as herein described.