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Malmberg

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[45] **Oct. 21, 1975**

[54] RAPID EXPOSURE OF MICROPATTERNS WITH A SCANNING ELECTRON MICROSCOPE

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[73] Assignee: **Westinghouse Electric Corporation,** Pittsburgh, Pa.

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[21] Appl. No.: **426,393**

[52] **U.S. Cl.** .... **250/311;** 250/492 A
[51] **Int. Cl.**^{2} **H01J 29/00**
[58] **Field of Search** 250/492, 311, 397

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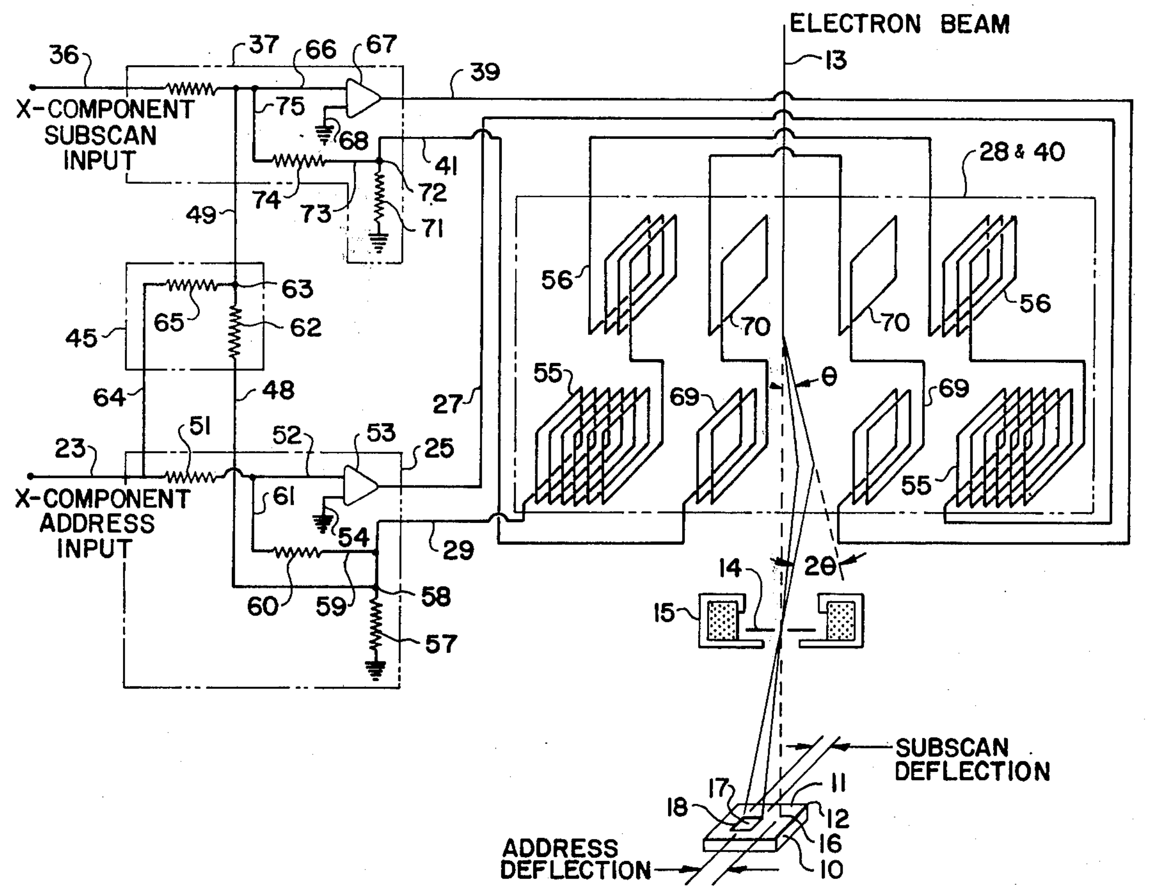
Assistant Examiner—B. C. Anderson
Attorney, Agent, or Firm—C. L. Menzemer

[57] ABSTRACT

A micropattern is rapidly located and produced with precision on a major surface of a member with a scanning electron microscope. The major surface of the member is prepared with an electron resist layer. The electron beam of the scanning electron microscope is located at successive coordinate address positions at the major surface by address generator means and low speed deflection means for irradiation of a precision pattern in the electron resist layer by contiguous subscans. At each coordinate address, the electron beam is moved through a subpattern about the coordinate address position by a subscan generator means and high speed deflection means. Preferably, the electron beam is rapidly stabilized at each address position by generating compensating electrical signals related to transient errors from the low speed deflection means on inputting the address signals, and inputting the compensating electrical signals to the high speed deflection means.

4 Claims, 11 Drawing Figures



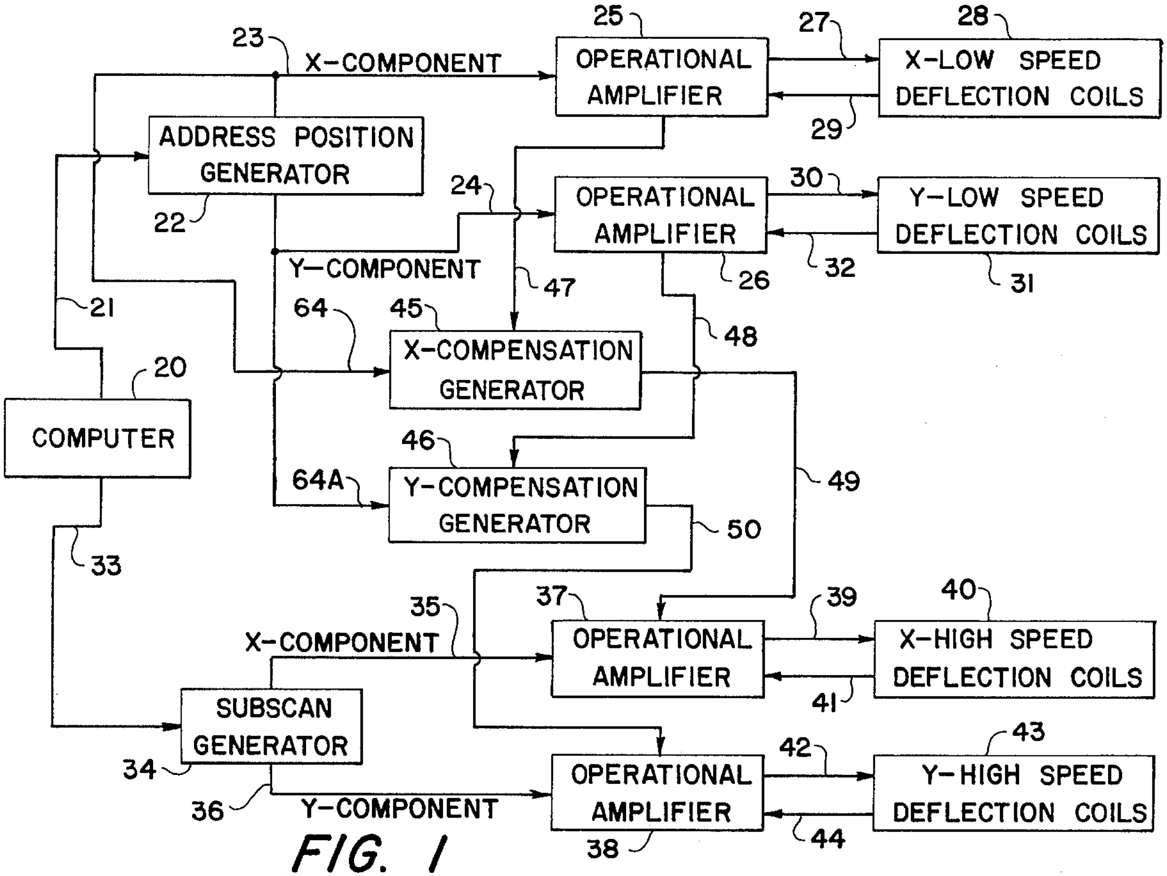

COMPUTER
20
21
33
ADDRESS POSITION GENERATOR
22
23
X-COMPONENT
Y-COMPONENT
24
OPERATIONAL AMPLIFIER
25
27
29
X-LOW SPEED DEFLECTION COILS
28
OPERATIONAL AMPLIFIER
26
30
32
Y-LOW SPEED DEFLECTION COILS
31
47
48
64
45
X-COMPENSATION GENERATOR
46
64A
Y-COMPENSATION GENERATOR
49
50
35
X-COMPONENT
SUBSCAN GENERATOR
34
36
Y-COMPONENT
37
OPERATIONAL AMPLIFIER
39
41
X-HIGH SPEED DEFLECTION COILS
40
OPERATIONAL AMPLIFIER
38
42
44
Y-HIGH SPEED DEFLECTION COILS
43

FIG. 1

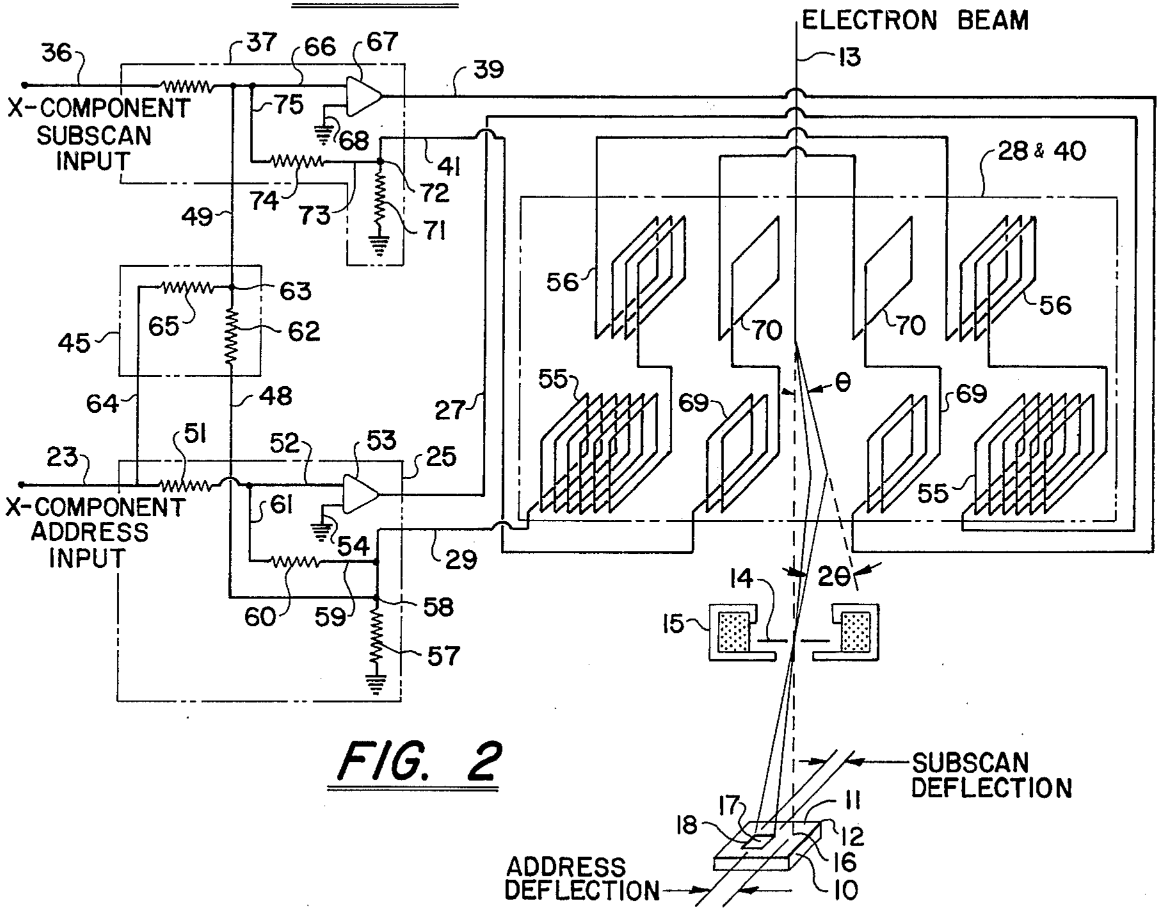

ELECTRON BEAM
13
36
X-COMPONENT SUBSCAN INPUT
37
66
67
39
75
68
41
72
74
73
71
49
28 & 40
63
65
62
45
56
70
70
56
64
48
θ
55
69
69
55
27
23
51
52
53
25
X-COMPONENT ADDRESS INPUT
61
54
29
60
59
58
57
14
26
15
SUBSCAN DEFLECTION
17
11
18
12
16
10
ADDRESS DEFLECTION

FIG. 2

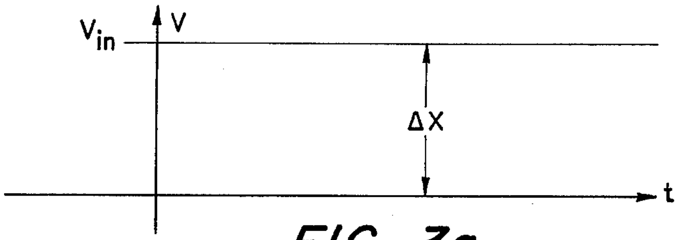


FIG. 3a

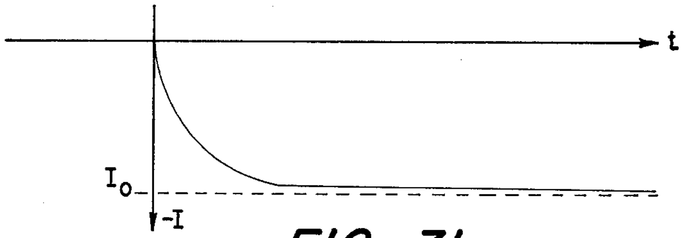


FIG. 3b

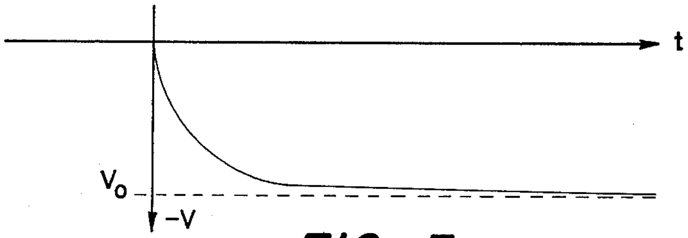


FIG. 3c

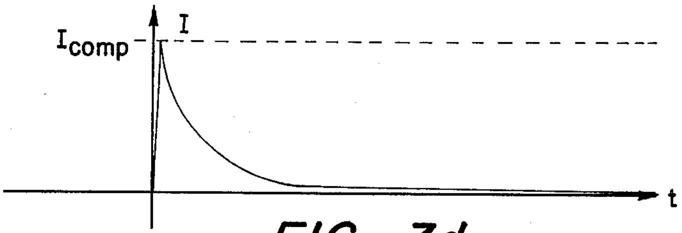


FIG. 3d

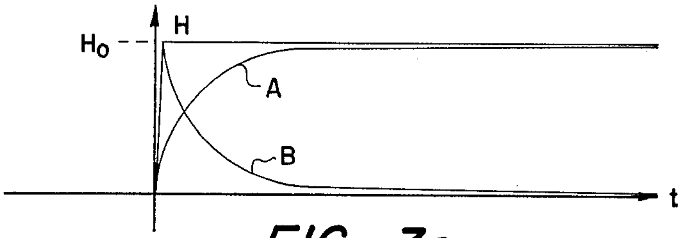


FIG. 3e

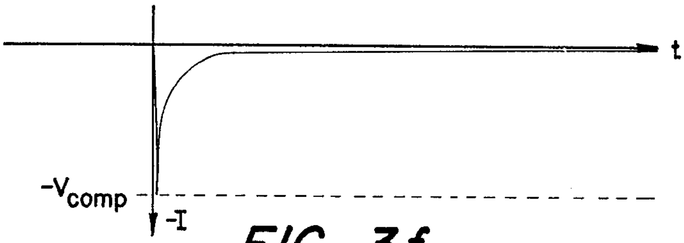


FIG. 3f

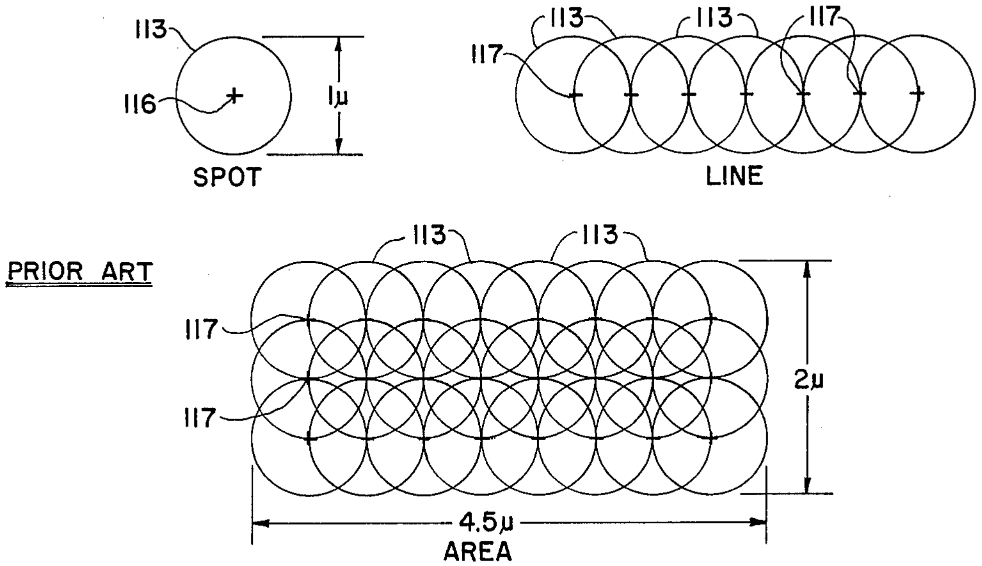


FIG. 4

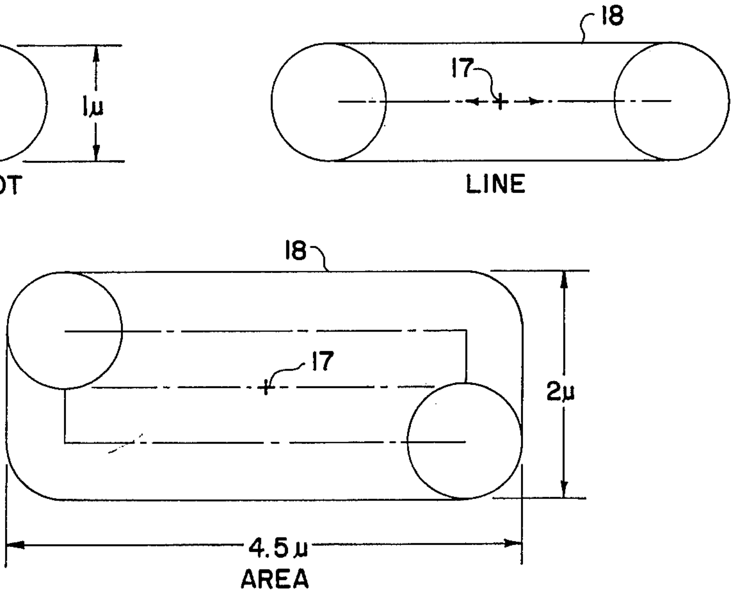


FIG. 5

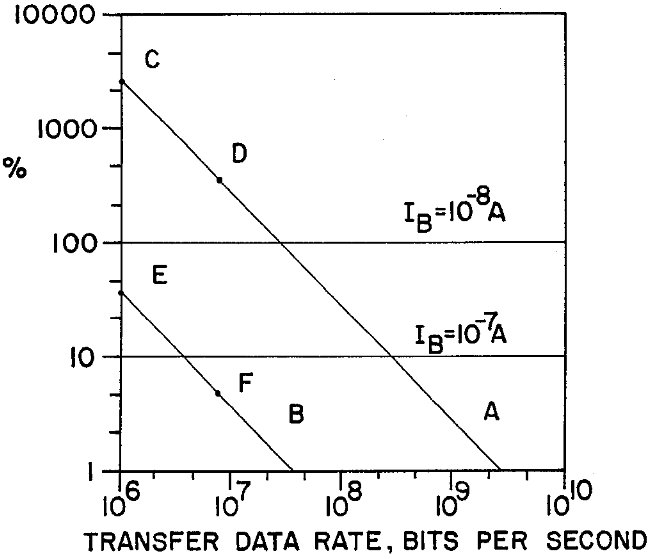


FIG. 6

RAPID EXPOSURE OF MICROPATTERNS WITH A SCANNING ELECTRON MICROSCOPE

GOVERNMENT CONTRACT

The present invention was made in course of or under Government Contract NAS 8-20770. The invention described herein was made in the performance of work under said NASA contract and is subject to the provision of Section 305 of the National Aeronautics and Space Act of 1958, Public Law 84-568 (72 Stat. 435; 42 USC 2457).

FIELD OF THE INVENTION

The invention relates to the making of integrated circuits and other micro-miniature electronic components with submicron accuracy.

BACKGROUND OF THE INVENTION

The present invention is an improvement on the electron beam fabrication system described in U.S. Pat. No. 3,679,497, granted July 25, 1972.

The scanning electron microscope of such fabrication system involves the use of a finely focused electron beam, e.g. 1 micron in diameter, to generate a planar component having submicron accuracy in an electron sensitive resist layer. The electron beam is automatically moved through the micropattern by discrete overlapping positions, point-by-point, on command from a digital computer. The beam control information is typically stored on a magnetic tape which is fed into the computer where it is used to generate coordinate electrical address signals which are inputted to deflection means and in turn deflect the electron beam to the successive address positions. While such scanning electron microscope system can be used to directly develop a high resolution micropattern in an electron resist in making integrated circuits, the electron beam fabrication system involves the use of the scanning electron microscope to make a patterned photocathode source (called an "electromask") for the electron image projection system.

The main difficulty is that the scanning electron microscope takes a very long time period to expose a complete micropattern. The operating speed depends on a combination of a number of factors: beam current and diameter, speed of beam deflection, electron resist sensitivity, and data rate of the system. Under some conditions, data rate is the primary limiting factor. To illustrate, exposure of the pattern field measuring 2000 × 2000 microns with a 1 micron-diameter scanning beam typically requires that the field be subdivided on 0.5 micron centers into a raster of 4000 × 4000 addresses. Such as raster requires 12 bits of information in the X direction and 12 bits of information in the Y direction or a total of 24 bits of information simply to locate each address in the computer. The machine word, i.e. the number of bits at each address location, is of course, much longer by virtue of the operation information bits as well as the parity code bits, word mark bits and machine instruction codes. Thus, in the point-by-point exposure of 4000 × 4000 addresses, a typical machine word may contain as many as 48 bits. The exposure time is in turn fixed by the time required for the system to generate or process the total bits, i.e. 48 × 4000 × 4000, together with intervening exposure times.

The point-by-point exposure with the scanning electron beam is also limited in resolution by the geometry of the beam. The beam is typically circular in cross-section and 1 micron in effective diameter. In the exposure in 0.5 micron increments, a slightly scalloped edge is formed along the edge or edges of the exposures. The edge resolution of the system is therefore restricted by the variation of the scallops. The variation can be reduced by placing the address or exposure points closer together. However, this further extends the exposure time and, depending on the storage capacity of the computer, limits the scanning field of each raster.

These difficulties and disadvantages have been substantially reduced by the present invention. It greatly reduces the data rate requirements of the system by a high speed deflection of the electron beam through a subpattern at each address location, thereby reducing the number of machine words required for an entire field scan. And the invention reduces the size of the computer storage needed to expose a micropattern of a given size and, conversely, increases the scan field which can be exposed with a given size computer storage. Further, it minimizes the variations along the edges by causing the beam to sweep through a length at each address, thereby increasing edge resolution of the system.

SUMMARY OF THE INVENTION

An apparatus and method are provided for producing, in a relatively short period of time, a precisely located micropattern on a member by exposure with an electron beam of a scanning electron microscope.

The member is first prepared by applying over a major surface of the member and electron resist layer. That is, a layer of material that upon selective exposure to an electron beam becomes more or less soluble and preferably more or less etchant resistant (sometimes called an "electroresist"). The electron beam of small cross-sectional dimensions of the scanning electron microscope is located at an address position at the major surface of the member by generating address signals by address generator means, which typically includes a digital computer, and inputting the address signals to low speed deflection means to cause the electron beam to deflect to prescribed coordinates.

The located electron beam of the scanning electron microscope is then moved through a subpattern about the address position on the major surface of the member. The subscan movement is accomplished by generating subscan signals by a subscan generator means, which also typically includes a digital computer, and inputting the subscan signals to high speed deflection means to cause the electron beam to deflect through the prescribed subpattern.

The electron beam is thus repeatedly located at successive address locations and moved through contiguous subscan patterns until a prescribed micropattern is defined by differential solubility in the electron resist layer. Subsequently, the resist layer is developed in appropriate solvents, stabilized by thermal or chemical treatments, and the micropattern transferred to the electronic component by diffusion, etching or deposition.

Preferably, compensating generator means are additionally provided to more rapidly locate the electron beam at each address position. The compensation generator means generates a compensating electrical signals corresponding to the transient electrical error signal produced by inputting the address signals to the low speed deflection means. Cross-over means are then provided for inputting the compensating electrical signal to the high speed deflection means. By this arrangement, the electron beam is addressed at each address location more rapidly than simply inputting the address signal to the low speed deflection means.

Other details, objects and advantages of the invention will become apparent as the following description of the presently preferred embodiments of the invention and the presently preferred methods of using the invention proceeds.

BRIEF DESCRIPTION OF THE DRAWINGS

In the accompanying drawings, the present preferred embodiments of the invention and present preferred methods of practicing the same are illustrated in which:

FIG. 1 is a block diagram of the electrical circuit for exposing a micropattern on a member with a scanning electron microscope in accordance with the present invention;

FIG. 2 is a schematic showing the details of the present invention in one ordinate of the deflection means of said blocks of FIG. 1;

FIGS. 3A through 3F shows the transient electrical signals at various points in the circuit of FIG. 2;

FIG. 4 is a schematic showing exposure of a micropattern on a member with a scanning electron microscope in accordance with the prior art;

FIG. 5 is a schematic showing exposure of a micropattern on a member with a scanning electron microscope in accordance with the present invention; and

FIG. 6 is a graph illustrating the relative increase in exposure rate with a scanning electron microscope utilizing the present invention.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

Referring particularly to FIGS. 1 and 2, the member **10** is first prepared by applying over a major surface **11** thereof an electron resist layer **12.** An electron beam **13** of an electron beam microscope is projected through aperture **14** of final lens **15** of the microscope onto resist layer **12** on the major surface of member **10** at **16.** Electron beam **13** is deflected to an address position **17** at the major surface of member **10** by deflection means, fully described hereinafter, on inputting address signals to said deflection means from address generator means hereinafter described. Electron beam **13** is then moved through a subscan **18** at major surface **11** of member **10** by deflection means fully described hereinafter on inputting subscan signals to said deflection means from subscan generator means hereinafter described.

Referring to FIG. **1,** a schematic is shown which illustrates the deflection and subscan circuitry of the present invention. Both address and subscan commands are preferably formed into a computer program and used to program digital computer **20.** The address and subscan at each address location may be provided in one machine word or consecutive machine words. In any case, electrical machine word signals for the address location are inputted by computer **20** through data bus **21** to address position generator **22.** Address position generator **22** is actuated by the machine word electrical signals to generate electrical signals corresponding to the orthogonal coordinates (i.e. X and Y components) of the address location **17** for electron beam **13** at major surface **11** of member **10.** Coordinate X and Y components of the address signal are then separately inputted via leads **23** and **24,** respectively, to operational amplifiers **25** and **26,** respectively, of the low speed deflection means. The low speed deflection means also includes X-low speed deflection coils **28** and Y-low speed deflection coils **31,** which are orthogonally positioned in pairs symmetrically about electron beam **13,** to deflect electron beam **13** to the prescribed address position **17.** The X and Y components of the address signal are inputted from amplifiers **25** and **26** through leads **27** and **30** to deflection coils **28** and **31,** respectively, and fed back through leads **29** and **32,** respectively, to amplifiers **25** and **26,** respectively.

Locating electron beam **13** at address position **17,** the computer **20** inputs electrical machine word signals for subscan through data bus **33** to actuate subscan generator **34.** Generator **34** is caused by the machine word electrical signals to generate electrical signals in X and Y components, i.e. which are orthogonally related, corresponding to the movement of the electron beam through subscan or subpattern **18** at the address position **17** on major surface **11** of member **10.** The X and Y components of the subscan electrical signals are inputted through leads **35** and **36,** respectively, to operational amplifiers **37** and **38,** respectively, of the high speed deflection means. The high speed deflection means also includes X-high speed deflection coils **40** and Y-high speed deflection coils **43,** which are orthogonally positioned in pairs symmetrically about the electron beam and typically in the same coordinate system as low speed deflection coils **28** and **31,** to deflect the electron beam through the prescribed subscan or subpattern **18.** The X and Y components of the subscan electrical signals are inputted from amplifiers **37** and **38** through leads **39** and **42,** respectively, to deflection coils **40** and **43,** respectively, and are fed back through leads **41** and **44,** respectively, to amplifiers **37** and **38,** respectively.

Preferably, X and Y compensation generators **45** and **46** are additionally provided to rapidly position the electron beam at the address location **17.** The difficulty is that the low speed deflection means have substantial inductances which cause the inputted signals to asymptotically rise to the prescribed generated coordinate address signals. These transient signals cause a time lag in the positioning of the electron beam at each address location. Compensation generators **45** and **46** receive the respective X and Y transient electrical signals via leads **47** and **48,** respectively, from the feed back to operational amplifiers **25** and **26,** respectively, which signals are caused by the respective inductances of low speed deflection means. The compensating generators process said component transient signals to produce conjugate or compensating X and Y component electrical signals which are inputted through crossover leads **49** and **50** to operational amplifiers **37** and **38,** respectively, of the high speed deflection means. By these compensating inputs to high speed deflection means, high speed deflection coils **40** and **42** are caused to deflect electron beam **13** of the scanning electron microscope to the address location **17** on major surface **11** of member **10** much more rapidly and in turn substantially reduce the time required to position the electron beam at each address and, in turn, substantially reduce the time required to expose the described micropattern in the resist layer **12** on the major surface of member **10.**

Referring to FIG. 2, details are shown of the operational amplifiers, low and high speed deflection coils, and compensation generators. The details are shown of the X components of each device with their interconnections. It will be understood that a duplicate arrangement is provided for the Y components, with the Y-deflection coils **31** and **43** positioned in pairs perpendicular to the X-deflection coils **28** and **31** symmetrically about the electron beam **13.**

The X component of the address signal is inputted through lead **23** to operational amplifier **25** of the low speed deflection means. The signal has a voltage step-function wave form as shown in FIG. 3A, where the voltage corresponds to the desired incremental deflection of the electron beam in the X-component axis. In amplifier **25,** the voltage step-function wave form is converted to a current step-function wave form by passage through resistor **51,** and the current step function is inputed through lead **52** to amplifier device **53.** Device **53** has a high current output of the opposite polarity from the input and, as an operational amplifying device, operates to bring the two input terminals to zero. The other input lead **54** to amplifier device **53** is grounded. Thus, the feedback circuit as hereinafter described is such as to bring to input at lead **52** to ground or zero volts.

The output of amplifier device **53** is a high current step-wave signal which is inputted via lead **27** to lower and upper X-low speed deflection coil pairs **55** and **56** of low speed deflection means. Deflection coil pairs **55** and **56** are symmetrically positioned about electron beam **13** opposite each other. The electron beam is thus caused to deflect by upper coil pair **56** through an angle θ opposite to the direction of desired deflection and then caused to deflect by pair coil **55** through an angle 2θ in the opposite direction to provide the described deflection to the address location **17** at major surface **11** of member **10.** The difference in deflections by the lower and upper coils **55** and **56** is caused by providing the lower coils with twice the ampere turns of the upper coils. The purpose of this double deflection is to maintain the electron beam centered in the aperture **14** of final lens **15** of the scanning electron microscope.

Because of the inductance of the low speed deflection coils, the current signal through deflection coils **55** and **56** is not a step-function wave form. Rather, the signal is a transient which asymptotically approaches the current signal desired for the X component of the address location as shown in FIG. 3B. This transient is fed back from low speed deflection coils **55** and **56** through lead **29** to amplifier **25,** where the signal is processed through resistor **57** to ground. By this arrangement, the conjugate voltage signal shown in FIG. 3C is formed at **58,** which is fed back through lead **59** and resistor **60** (i.e. a matching resistor for resistor **51**) to convert the wave form to a current transient signal, and through lead **61** to be added to the inputted step-current waveform in lead **52** to approach zero.

The conjugate voltage signal at **58** is also inputted to X-compensation generator **45** through lead **47,** where the signal passes through resistor **62** to convert it to a current wave form. Also inputted to generator **45** through lead **64** from address position generator **22** is the original address signal as shown in FIG. 3A. Said address signal passes through resistor **65** to convert the signal to a current wave form and thereafter add it to the converted conjugate current signal from the feedback of operational amplifier **25** at **63.** The sum current signal formed is the compensating signal, as shown in FIG. 3D, which is outputted to operational amplifier **37** of the high speed deflection means through lead **49.**

In the operational amplifier **37,** the compensating signal is inputted through lead **66** to the amplifier device **67.** Device **67** has a high current output of the opposite polarity from the input and, as an operational amplifying device, operates to bring the two input terminals to zero. The other input lead **68** to amplifier device **67** is grounded. Thus, the feedback circuit as hereinafter described is such as to bring the input at lead **66** to ground or zero volts. The output of amplifier device **67** is a high current pulse signal which is inputted via lead **39** to lower and upper X-high speed deflection coil pairs **69** and **70** of the high speed deflection means. Deflection coil pairs **69** and **70** are low inductance coils positioned symmetrically about electron beam **13** opposite each other, with lower coil pair **69** having twice the ampere turns of upper coil pair **70.** The amplified compensation pulse forms a magnetic field between the coils as shown by curve B of FIG. 3E, which complements the magnetic field formed therebetween by low speed deflection coil pairs **55** and **56** shown by curve A of FIG. 3E, to form a net deflection magnetic field as shown in FIG. 3E which causes virtually a step deflection of electron beam **13** through an angle θ and then an angle 2 θ to the address location **17.** It is anticipated that the compensation signal will thus permit deflection times on the order of 100 nanoseconds for typical deflection increments. This feature in turn becomes of considerable importance in reducing the exposure time of the entire micropattern when the accumulated time saved on each deflection is summed.

After deflection to the address location **17,** the X component of the subscan signal is inputted through lead **36** to operational amplifier **37** of the high speed deflection means. The signal will be a voltage modulated signal with the modulation corresponding to changes along the X coordinate of the electron beam deflection as the beam moves through the prescribed subscan **18** about the address position **17.** The voltage signal inputted is converted to a current modulated signal by resistor **76** and then inputted via lead **66** to amplifier device **67.** The output of device **67** is again a modulated high current which is inputted to lower and upper high speed deflection coil pairs **69** and **70.** The electron beam is again provided with a double deflection, first through an angle θ and then an opposite angle 2 θ, by providing the lower coils **69** with twice the ampere turns of upper coils **70.** The high speed coils have, however, substantially fewer ampere turns than low speed deflection coils **55** and **56** to enable the high speed deflection means to respond at much faster rates but deflecting the electron beam through much smaller angles than the low speed deflection means because of the smaller inductance and smaller magnetic field. The typical deflection in each coordinate of the subscan **18** is 8 microns; but it is contemplated that a deflection of up to 32 microns may be provided by the high speed deflection means. The restricting factor in this connection is that the greater the deflection, the higher the inductance of the coils, and the slower the response on the subscan. Thus, 32 microns is considered a practical upper limit of subscan deflection in either coordinate with presently available deflection means.

Because of the inductance of the high speed deflection coils, the current signal through deflection coils **55** and **56** is not quite the same as the input signal. Rather, the signal is a transient which asymptotically approaches the current signal desired for the X component of the subscan as shown in FIG. 3F. This transient is fed back from high speed deflection coils **69** and **70** through lead **41** to amplifier **37**, where the signal is processed through resistor **71** to ground. By this arrangement, the conjugate transient voltage signal shown in FIG. 3F is formed at **72**, which is fed back through lead **73** and resistor **74** (i.e. a matching resistor for resistor **76**) to convert the wave form to a current transient signal, and through lead **75** to be added with the inputted step-current wave form in lead **66** to approach zero.

It should be observed that the double deflection system as shown in FIG. **2** is only one way of carrying out the present invention. The double deflection system may alternatively form electric fields by the high speed deflection means instead of the magnetic fields as shown, or both low and high speed deflection means may be provided with the same coils by using component signals of different frequencies for the address and subscan deflections. Further, the deflection means may operate beyond the final lens **14** with a single set of coils to provide a single deflection directly to the address location and through the subscan. Preferably, however, the double deflection system as shown in FIG. **2** is used to reduce beam shape distortions in final lens **15** caused by off-axis beam transversal, while at the same time eliminating the necessity for interposing space-consuming deflection coils or electrodes between the final lens **14** and the member **10.**

Referring to FIGS. **4** and **5**, the results of the present invention are shown with reference to the prior art. Referring to FIG. **4,** the prior art method is shown of selectively exposing a micropattern with a scanning electron microscope address-by-address. FIG. **5** shows the corresponding exposures with the use of the subscan method herein described.

To illustrate, consider electron beam **113** having center **116** and an effective exposure diameter of 1 micron. The electron beam is deflected to successive address locations **117,** ½ micron aprat, to provide a relative smooth exposed edge. However, as can be seen from FIG. **4,** the geometry still causes scallop variations to occur along the edge formed by exposure of beam **113** at successive address locations **117.** Moreover, to address and expose, for example, a 1 cm^2 member a total of 4 × 10^8 addresses must be provided, and to expose a 2 × 4.5 micron area as shown in FIG. **4,** 24 addresses are needed. And with a typical address work containing 48 bits for exposure of a 2000 × 2000 micron field, it is observed that the scanning microscope is limited by the storage capacity of the signal generator system, as well as the data rate which extends the exposure time.

Referring to FIG. **5,** the contrasting use of the present invention to expose a micropattern with a scanning electron microscope is clearly shown. Electron beam **13** has center **16** which is deflected to address locations **17** and is then deflected at high speeds through subscans **18** for a linear exposure or a rectangular exposure. Instead of 24 address locations to expose the 2 ×4.5 micron area, only one address location and a subscan is needed, which subscan can be provided by either the same machine word as for the address location or by a successive machine word. The rate of exposure of a micropattern is in turn substantially increased. It can be seen from FIG. **5** that subscans can be made contiguous simply by spacing the address locations. Further, the variations at the edge of the exposure is essentially eliminated, thus increasing the edge resolution of the exposure system.

Referring to FIG. **6,** a quantitative comparison is shown between the exposure time of the present invention and the exposure time of the prior art address-by-address system. A 48-bit machine word is assumed for the prior art system and a 64-bit machine word is assumed for the present invention.

The ordinate of FIG. **6** has been labeled as the time to expose 25 percent of a 2 inch square resist layer (6 cm^2) expressed in minutes. It will be seen that to accomplish the exposure a data rate exceeding 2 × 10^7 bits per second is required. This rate will just match the exposure speed permitted by an assumed beam current of 10^{-8} amps and an electron resist sensitivity of 10^{-5} coulombs per square cm. By the use of a subscan system of controlled size at each principal beam address, an area equivalent to many point-by-point addresses may be exposed with only one address, as shown in FIG. **5.** In this way the number of addresses required for a small geometric unit can be reduced to 1 from a number equal to 4 times the area of the unit in square microns. By using a subscan, which can be adjusted in dimension independently in X-Y directions from 1 to 16 microns, FIG. **6** shows (comparing curves A and B) that address economies ranging up to 1000-fold can be obtained. Points C and E, and points D and F show a direct comparison of the reduced exposure time with a typical disc memory (DDC-7302) and typical mini-digital computer (PDP-8), respectively.

As can be seen from inspection of FIG. **6,** typical exposure times for a 2 inch square resist layer may approach 10 minutes or less assuming a 10^{-7} amp beam current, 10^{-5} coulombs per centimeter resist sensitivity, a data rate of 4 × 10^6 bits per second and a high speed dual-deflection system as described hereinbefore. The use of such as system to prepare device patterns for complex integrated circuits and large scale integration will reduce the costs of designing and fabricating such circuits even in small custom lot quantities to an almost insignificant level as compared with similar costs using address-by-address electron scanning technology. The principal component of such costs at present is computer time. However, the net effect of present invention is to reduce by orders of magnitude the costs of operating such computers in micropattern exposures.

While presently preferred embodiments have been shown and described with particularity, it is distinctly understood that the invention may be otherwise variously embodied and performed within the scope of the following claims.

What is claimed is:

1. Apparatus for rapid exposure of a precision micropattern on a major surface of a prepared member with a scanning electron microscope comprising:

A. a prepared member having a major surface;

B. a scanning electron microscope positioned to project a small cross-sectional electron beam onto the major surface of the member;

C. an address generator means for generating electrical signals corresponding to successive coordinate addresses for exposing a precision pattern at the major surface of the member in successive subscans with the electron beam of the scanning electron microscope;

D. low speed deflection means for deflecting the electron beam of the scanning electron microscope to successive coordinate address positions at the major surface of the member responsive to the electrical signals from the address generator means;

E. a subscan generator means for generating electrical signals corresponding to successive subscans for exposing a precision subpattern at the major surface of the member about said coordinate address positions; and

F. high speed deflection means for deflecting the electron beam of the scanning electron microscope through subpatterns about said successive coordinate address positions at the major surface of the member responsive to the electrical signals from the subscan generator means.

2. Apparatus for rapid exposure of a precision micropattern on a major surface of a prepared member with a scanning electron microscope as set forth in claim 1 comprising in addition:

G. compensation generator means for generating compensating electrical signals corresponding to transient errors from inputting electrical signals from the address generator means to the low speed deflection means; and

H. cross-over means for inputting the compensating electrical signals to the high speed deflection means.

3. Apparatus for rapid development of a micropattern with a scanning electron microscope comprising:

A. a scanning electron microscope positioned to project a small cross-sectional electron beam;

B. an address generator means for generating electrical signals corresponding to successive coordinate addresses of successive subscans with the electron beam of the scanning electron microscope;

C. low speed deflection means for deflecting the electron beam of the scanning electron microscope to successive coordinate address positions responsive to the electrical signals from the address generator means;

D. a subscan generator means for generating electrical signals corresponding to successive subscans about said coordinate address positions; and

E. high speed deflection means for deflecting the electron beam of the scanning electron microscope through subpatterns about said successive coordinate address positions responsive to the electrical signals from the subscan generator means.

4. Apparatus for rapid development of a precision micropattern with a scanning electron microscope as set forth in claim 3 comprising in addition:

F. compensation generator means for generating compensating electrical signals corresponding to transient errors from inputting electrical signals from the address generator means to the low speed deflection means; and

G. cross-over means for inputting the compensating electrical signals to the high speed deflection means.

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