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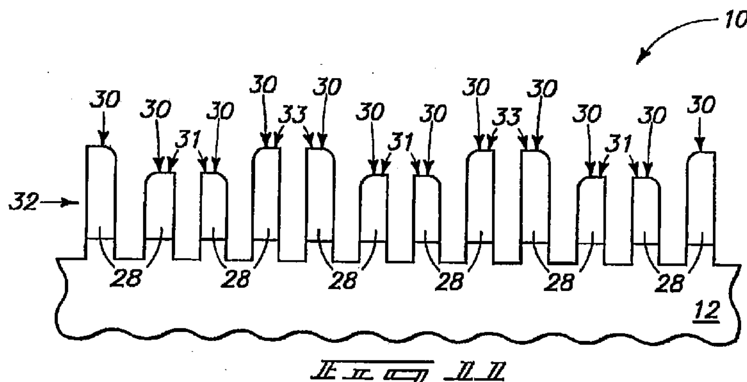

(57) Abstract: A method of fabricating a substrate includes forming spaced first features and spaced second features over a substrate. The first and second features alternate with one another and are spaced relative one another. Width of the spaced second features is laterally trimmed to a greater degree than any lateral trimming of width of the spaced first features while laterally trimming width of the spaced second features. After laterally trimming of the second features, spacers are formed on sidewalls of the spaced first features and on sidewalls of the spaced second features. The spacers are of some different composition from that of the spaced first features and from that of the spaced second features. After forming the spacers, the spaced first features and the spaced second features are removed from the substrate. The substrate is processed through a mask pattern comprising the spacers. Other embodiments are disclosed.

METHODS OF FABRICATING SUBSTRATES

TECHNICAL FIELD

5 Embodiments disclosed herein pertain to methods of fabricating substrate, for example as may be used in the fabrication of integrated circuitry.

BACKGROUND

Integrated circuits are typically formed on a semiconductor substrate such 10 as a silicon wafer or other semiconducting material. In general, layers of various materials which are either semiconducting, conducting or insulating are utilized to form the integrated circuits. By way of example, the various materials are doped, ion implanted, deposited, etched, grown, etc. using various processes. A continuing goal in semiconductor processing is to continue to 15 strive to reduce the size of individual electronic components thereby enabling smaller and denser integrated circuitry.

One technique for patterning and processing semiconductor substrates is photolithography. Such includes deposition of a patternable masking layer commonly known as photoresist. Such materials can be processed to modify 20 their solubility in certain solvents, and are thereby readily usable to form patterns on a substrate. For example, portions of a photoresist layer can be exposed to actinic energy through openings in a radiation-patterning tool, such as a mask or reticle, to change the solvent solubility of the exposed regions versus the unexposed regions compared to the solubility in the as-deposited 25 state. Thereafter, the exposed or unexposed regions can be removed, depending on the type of photoresist, thereby leaving a masking pattern of the photoresist on the substrate. Adjacent areas of the underlying substrate next to the masked portions can be processed, for example by etching or ion implanting, to effect the desired processing of the substrate adjacent the masking material. In certain 30 instances, multiple different layers of photoresist and/or a combination of photoresists with non-radiation sensitive masking materials are utilized.

The continual reduction in feature sizes places ever greater demands on the techniques used to form the features. For example, photolithography is

commonly used to form patterned features, such as conductive lines. A concept commonly referred to as "pitch" can be used to describe the sizes of the features in conjunction with spaces immediately adjacent thereto. Pitch may be defined as the distance between an identical point in two neighboring features of a
5 repeating pattern in a straight line cross section, thereby including the maximum width of the feature and the space to the next immediately adjacent feature. However, due to factors such as optics and light or radiation wave length, photolithography techniques tend to have a minimum pitch below which a particular photolithographic technique cannot reliably form features. Thus,
10 minimum pitch of a photolithographic technique is an obstacle to continued feature size reduction using photolithography.

Pitch doubling or pitch multiplication is one proposed method for extending the capabilities of photolithographic techniques beyond their minimum pitch. Such typically forms features narrower than minimum
15 photolithography resolution by depositing spacer-forming layers to have a lateral thickness which is less than that of the minimum capable photolithographic feature size. The spacer-forming layers are commonly anisotropically etched to form sub-lithographic features, and then the features which were formed at the minimum photolithographic feature size are etched
20 from the substrate.

Using such technique where pitch is actually halved, such reduction in pitch is conventionally referred to as pitch "doubling". More generally, "pitch multiplication" encompasses increase in pitch of two or more times and also of fractional values other than integers. Thus, conventionally, "multiplication" of
25 pitch by a certain factor actually involves reducing the pitch by that factor.

BRIEF DESCRIPTION OF THE DRAWINGS

Fig. 1 is a diagrammatic sectional view of a substrate in process in accordance with an embodiment of the invention.

Fig. 2 is a view of the Fig. 1 substrate at a processing step prior to that of Fig. 1.

Fig. 3 is a view of the Fig. 1 substrate at a processing step subsequent to that shown by Fig. 1.

Fig. 4 is a view of the Fig. 3 substrate at a processing step subsequent to that shown by Fig. 3.

Fig. 5 is a view of the Fig. 4 substrate at a processing step subsequent to that shown by Fig. 4.

Fig. 6 is a view of the Fig. 5 substrate at a processing step subsequent to that shown by Fig. 5.

Fig. 7 is a view of the Fig. 6 substrate at a processing step subsequent to that shown by Fig. 6.

Fig. 8 is a view of the Fig. 7 substrate at a processing step subsequent to that shown by Fig. 7.

Fig. 9 is a view of the Fig. 8 substrate at a processing step subsequent to that shown by Fig. 8.

Fig. 10 is a view of the Fig. 9 substrate at a processing step subsequent to that shown by Fig. 9.

Fig. 11 is a view of the Fig. 10 substrate at a processing step subsequent to that shown by Fig. 10.

Fig. 12 is diagrammatic sectional view of another substrate in process in accordance with an embodiment of the invention.

Fig. 13 is a view of the Fig. 12 substrate at a processing step subsequent to that shown by Fig. 12.

Fig. 14 is a view of the Fig. 13 substrate at a processing step subsequent to that shown by Fig. 13.

Fig. 15 is a view of the Fig. 14 substrate at a processing step subsequent to that shown by Fig. 14.

Fig. 16 is a view of the Fig. 15 substrate at a processing step subsequent to that shown by Fig. 15.

Fig. 17 is a view of the Fig. 16 substrate at a processing step subsequent to that shown by Fig. 16.

Fig. 18 is a diagrammatic sectional view of another substrate in process in accordance with an embodiment of the invention.

5 Fig. 19 is a view of the Fig. 18 substrate at a processing step subsequent to that shown by Fig. 18.

Fig. 20 is a view of the Fig. 19 substrate at a processing step subsequent to that shown by Fig. 19.

Fig. 21 is a view of the Fig. 20 substrate at a processing step subsequent
10 to that shown by Fig. 20.

Fig. 22 is a view of the Fig. 21 substrate at a processing step subsequent to that shown by Fig. 21.

Fig. 23 is a view of the Fig. 22 substrate at a processing step subsequent to that shown by Fig. 22.

15 Fig. 24 is a view of the Fig. 23 substrate at a processing step subsequent to that shown by Fig. 23.

Fig. 25 is a view of the Fig. 24 substrate at a processing step subsequent to that shown by Fig. 24.

Fig. 26 is a view of the Fig. 25 substrate at a processing step subsequent
20 to that shown by Fig. 25.

Fig. 27 is a view of the Fig. 26 substrate at a processing step subsequent to that shown by Fig. 26.

Fig. 28 is a diagrammatic sectional view of another substrate in process in accordance with an embodiment of the invention.

25 Fig. 29 is a view of the Fig. 28 substrate at a processing step subsequent to that shown by Fig. 28.

Fig. 30 is a view of the Fig. 29 substrate at a processing step subsequent to that shown by Fig. 29.

Fig. 31 is a view of the Fig. 30 substrate at a processing step subsequent
30 to that shown by Fig. 30.

Fig. 32 is a view of the Fig. 31 substrate at a processing step subsequent to that shown by Fig. 31.

DETAILED DESCRIPTION OF EXAMPLE EMBODIMENTS

Some embodiments of methods of fabricating a substrate in accordance with the invention, for example in forming integrated circuitry, are described initially with reference to Figs. 1-11. Referring to Fig. 1, a substrate, for
5 example a semiconductor substrate, is indicated generally with reference numeral 10. In the context of this document, the term "semiconductor substrate" or "semiconductive substrate" is defined to mean any construction comprising semiconductive material, including, but not limited to, bulk semiconductive materials such as a semiconductive wafer (either alone or in assemblies
10 comprising other materials thereon), and semiconductive material layers (either alone or in assemblies comprising other materials). The term "substrate" refers to any supporting structure, including, but not limited to, the semiconductive substrates described above.

Substrate 10 is depicted as comprising material 12 which will ultimately
15 be processed through a mask pattern formed thereover. Material 12 may be homogenous or non-homogenous, for example comprising multiple different composition regions and/or layers. Spaced first features 14 have been formed over substrate 12. Any suitable material is contemplated, and whether homogenous or non-homogenous. In the context of this document, “spaced”
20 refers to the lateral direction as opposed to vertically or otherwise. Spaced first features 14 may be patterned/formed by any existing or yet-to-be-developed manner, with photolithographic patterning using photoresist (whether positive, negative or dual-tone resist resulting from single or multi-pattern lithography) being an example. Further, spaced first features 14 may be formed by any
25 technique described below. In one example, spaced first features 14 may be in the form of elongated lines, for example running parallel one another over at least some portion of the substrate as would be viewed in a top-down view (not shown).

Further in one embodiment, spaced first features 14 may result from
30 lateral etching/trimming of wider features. For example, Fig. 2 depicts substrate 10 at a processing step prior to that of Fig. 1. Such is shown as comprising spaced mask features 16, for example comprising, consisting essentially of, or consisting of photoresist, having been fabricated over substrate 12 in a repeating pattern of a pitch “P”. Pitch P may be equal to, greater than,

or less than the minimum photolithographic resolution with which substrate 10 is fabricated. Regardless, spaced mask features 16 of Fig. 2 have been laterally trimmed to reduce their respective widths to produce the example construction of Fig. 1 which comprises spaced first features 14. Such may be conducted by an isotropic etch which removes material approximately equally from the sides and tops of spaced mask features 16. Alternately, chemistry and conditions may be used which tends to etch greater material from the lateral sides of spaced mask features 16 than from the respective tops. Alternately, chemistries and conditions may be used which tends to etch greater material from the tops of spaced mask features 16 than from the lateral sides.

For example, the construction depicted by Fig. 1 can be derived by plasma etching the substrate of Fig. 2 within an inductively coupled reactor. Example etching parameters which will achieve essentially isotropic etching where material of spaced mask features 16 is photoresist and/or other organic-comprising material are pressure from about 2mTorr to about 50mTorr, substrate temperature from about 0°C to about 110°C, source power from about 150 watts to about 500 watts, and bias voltage at less than or equal to about 25 volts. An example etching gas is a combination of Cl_2 from about 20sccm to about 100sccm and O_2 from about 10sccm to about 50sccm. Where material of spaced mask features 16 comprises photoresist, such will isotropically etch mask features 16 at a rate from about 0.2 nanometers per second to about 3 nanometers per second. While such an example etch is essentially isotropic, greater lateral etching of the spaced mask features will occur as two sides are laterally exposed as compared to only a single upper surface thereof.

If even more lateral etching is desired in comparison to vertical etching, example parameter ranges in an inductively coupled reactor include pressure from about 2mTorr to about 20mTorr, source power from about 150 watts to about 500 watts, bias voltage at less than or equal to about 25 volts, substrate temperature of from about 0°C to about 110°C, Cl_2 and/or HBr flow from about 20sccm to about 100sccm, O_2 flow from about 5sccm to about 20sccm, and CF_4 flow from about 80sccm to about 120sccm.

It may be desired that the stated etching provide greater removal from the top of the spaced mask features than from the sides, for example to either achieve equal elevation and width reduction or more elevation than width

reduction. The example parameters for achieving greater etch rate in the vertical direction as opposed to the lateral direction includes pressure from about 2mTorr to about 20mTorr, temperature from about 0°C to about 100°C, source power from about 150 watts to about 300 watts, bias voltage at greater
5 than or equal to about 200 volts, Cl_2 and/or HBr flow from about 20sccm to about 100sccm, and O_2 flow from about 10sccm to about 20sccm.

The example Figs. 1 and 2 embodiments depict the respective features as having equal shapes and widths relative one another in the depicted cross section, as well as equal spacing therebetween. Such is not, however, required
10 in this or other embodiments.

Outermost surfaces of spaced first features 14 may be treated, for example to provide resistance to etching using solvents or other etching chemistries which may be used to etch other materials on the substrate subsequently. Any such treating, if conducted, may depend on composition of
15 first features 14 and may modify composition of spaced first features 14 only proximate their outermost surfaces, or internally thereof including the possibility of modifying composition of the entirety of spaced first features 14. For example, first features 14 might be annealed to harden outermost surfaces thereof, and/or promote cross-linking when formed of polymer material.

20 As an additional example, spaced first features 14 may be exposed to a fluorine-containing plasma effective to form a hydrogen and fluorine-containing organic polymer coating (not shown) about outermost surfaces thereof, for example where features 14 comprise photoresist and/or other organic material. Such a coating may be deposited as a layer over features 14, and/or result from
25 transformation of the outer material of features 14 to form a coating independent of adding thickness to features 14. Regardless, the fluorine-containing plasma might be generated either one or both of within a chamber within which substrate 10 is received and remote of a chamber within which substrate 10 is received. If plasma generation occurs within a chamber in which the substrate
30 is received, such might by way of example include an inductively coupled plasma generating reactor or a capacitively coupled plasma generating reactor. Other existing or yet-to-be-developed plasma systems may also be used. Example gases which may be used for forming the fluorine-containing plasma include at least one of a fluorocarbon (i.e., CF_4, C_4F_6, C_4F_8), a

hydrofluorocarbon (i.e., CH_2F_2, CHF_3), and NF_3, including any mixtures thereof. Inert gases may also be added. In an inductively coupled reactor, example parameters include pressure from about 1mTorr to about 20mTorr, substrate temperature from about 0°C to about 110°C, source power from about 150 watts
5 to about 800 watts, and bias voltage less than or equal to about 50 volts. An example total flow rate for the fluorine-containing gas into the reactor is from about 20 sccm to about 150 sccm. In a more specific example, CF_4 and CH_2F_2 are both flowed into the reactor, for example CF_4 from about 20 sccm to about 120 sccm and CH_2F_2 from about 5 sccm to about 25 sccm. O_2 may or may not
10 also be used with the gases to form the fluorine-containing plasma. An example O_2 flow rate is from 0 sccm to about 10 sccm.

Exposure to the fluorine-containing plasma may or may not change the lateral dimensions of spaced first features 14 in the depicted cross section and may or may not change the spacing between adjacent of first features 14 in the
15 depicted cross section. By way of example only in the above example process, pressure at the higher end of the stated 1mTorr to 20mTorr range in combination with flowing CH_2F_2 at the higher end of the stated 5 sccm to 25 sccm range would tend to increase width of spaced first features 14 and reduce width of spaces therebetween.

20 Referring to Fig. 3, a first material 18 has been deposited over spaced first features 14. Such is of some different composition from that of spaced first features 14, and may be conductive, semiconductive, or insulative, including any combination thereof. Examples include silicon dioxide, silicon nitride, organic antireflective coatings, inorganic antireflective coatings, polysilicon,
25 titanium or titanium nitride, including any combination thereof.

Referring to Fig. 4, a second material 20 has been deposited over first material 18, and is of some different composition from that of first material 18. Such may be of the same or some different composition from that of spaced first features 14. Such may be formed to have a planar or non-planar outermost
30 surface, with a planar outermost surface 21 being shown. Such may, for example, result from the inherent deposition of material 20 in a liquid-fill manner, or from deposition of one or more conformal layers followed by some sort of polished-back or etch-back thereof. Example second materials 20 include photoresist and other polymers, for example, polystyrene,

polymethylmethacrolate and polysiloxane. Second material 20 may or may not be homogenous.

Referring to Fig. 5, only a portion of second material 20 has been removed to expose first material 18 and form regions of spaced second material 20 received over first material 18. Any suitable etching technique and conditions can be selected by the artisan. Some of first material 18 may or may not be etched during the processing to produce the construction of Fig. 5.

Referring to Fig. 6, first material 18 has been etched from between spaced second material 20 and spaced second features 22 have been formed which comprise spaced second material 20 received over first material 18. Second features 22 are spaced from first features 14. Any suitable substantially anisotropic etching chemistry and conditions can be selected by the artisan for producing the Fig. 6 construction. In one embodiment, second material 20 has a planar outermost surface prior to any removing of second material 20. In one embodiment, no etch mask other than first material 18 is received over any of spaced first features 14 during such etching of first material 18. In one embodiment, no etch mask is received anywhere over the substrate during such etching of first material 18.

Referring to Fig. 7, width of spaced second features 22 from Fig. 6 has been laterally trimmed. Example techniques for doing so include etching of second material 20 and first material 18. Some lateral width trimming of spaced first features 14 may also occur during the laterally trimming of width of spaced second features 22. Alternately and as shown in the processing going from Fig. 6 to Fig. 7, no lateral width trimming of spaced first features 14 has occurred during the laterally trimming of width of spaced second features 22. For example, treating at least outermost surfaces of first features 14 as described above, and depending on composition of second material 20 and first material 18, may be conducted to provide some or near infinite etch resistance to spaced first features 14 in producing the construction of Fig. 7.

Regardless, the example lateral trimming of Fig. 7 may or may not result in equal width of each spaced second feature 22, and/or equal width of second material 20 and first material 18 of each spaced second feature 22. Also, all of spaced first features 14 are shown as being of the same respective starting dimensions relative one another, and second features 22 are also shown to be of

the same respective starting dimensions relative one another, but such is not required. Further and regardless, the act of lateral trimming may be simultaneously conducted in degree of the first and second materials relative to one another, and/or multiple different etching chemistries may be used depending upon the compositions of second material 20 and first material 18. For example where composition of materials 20 and 18 are both organic, example processing which may be used to laterally trim width of second material 20 and first material 18 of spaced second features 22 substantially equally includes any of that described above in producing the construction of Fig. 1 from that of Fig. 2. Further and regardless, some reduction or no reduction of the respective thicknesses of spaced first features 14 and spaced second features 22 may occur during the act of lateral trimming.

In one embodiment, a method of fabricating a substrate includes forming spaced first features and spaced second features over a substrate, where the first and second features alternate with each of the other, and which are spaced relative one another. Width of the spaced second features is laterally trimmed to a greater degree than any lateral trimming of width of the spaced first features while/during the act of laterally trimming width of the spaced second features.

Spacers are formed on sidewalls of the spaced first features and on sidewalls of the spaced second features, and which are of some different composition from that of the spaced first features and from that of the spaced second features. Any existing or yet-to-be developed technique may be used, with one example being shown in Figs. 8 and 9. Referring to Fig. 8, a spacer-forming layer 28 has been deposited over spaced first features 14 and spaced second features 22 of the Fig. 7 construction. Any suitable material is contemplated wherein at least some, if not all, of spaced first features 14 and spaced second features 22 may be selectively etchable relative thereto.

Referring to Fig. 9, spacer-forming layer 28 has been anisotropically etched to form spacers 30 and outwardly expose spaced first features 14 and spaced second features 22. In one embodiment, such may be conducted in a maskless manner wherein no mask is received over the substrate during etch of spacer-forming layer 28 to produce the Fig. 9 construction.

Referring to Fig. 10, first features 14 (not shown) and second features 22 (not shown) have been removed from the substrate. An example technique

includes etching, with the artisan being capable of choosing any existing or yet-to-be developed etching chemistries and conditions. Fig. 10 depicts one example embodiment where a mask pattern 32 which comprises spacers 30 has been formed over substrate 12. Such also depicts an example embodiment wherein spacers 30 have at least two different thickness, although common thickness or more variability in thickness may result. In one embodiment, spacers 30 of mask pattern 32 comprise alternating first and second pairs 31, 33, respectively, of immediately adjacent spacers. Spacers 30 of first pair 31 have a first common thickness, and spacers 30 of second pair 33 have a second common thickness. The first and second thicknesses are different.

The above processing may be conducted, for example, to result in a pitch multiplication which may or may not be sub-lithographic. Regardless, the Figs. 1-10 embodiments depict mask pattern 32 (Fig. 10) having been formed to have a pitch which is one-fourth (an integer factor of 4) that of pitch "P" of spaced mask features 16 in Fig. 2. Any degree of pitch reduction (including non-integer fractional reduction) in Figs. 1-10, or otherwise, will of course be in large part determined on the degree of lateral trimming that may occur of spaced features (for example in forming the Figs. 2, 6 and 7 constructions) in combination with thickness of the deposited layers to produce the features and the spaces between the features. For example, the deposition thickness of first material 18 in Fig. 3 in combination with the etching technique to produce the construction of Fig. 6 impacts width of spaced second features 22 in Fig. 6. Further and regardless, some or all of first features 16 and/or second features 22 may be further laterally trimmed after forming the Fig. 7 construction. Further, spacers 30 of Fig. 10 may be laterally trimmed by the act of removing first features 14 and second features 22, and/or subsequently thereafter by a dedicated lateral trimming step.

The mask pattern comprising the spacers is used to process the substrate received elevationally there-below through such mask pattern. Such processing may constitute any existing or yet-to-be developed technique, with etching and/or ion implanting being specific examples. Fig. 11 depicts one example of such processing wherein mask pattern 32 has been used as an etch mask while etching into material 12 of substrate 10.

Additional embodiments are next described with reference to Figs. 12-17. Fig. 12 depicts an alternate embodiment substrate fragment 10a corresponding in processing sequence to that of Fig. 8. Like numerals from the first described embodiments have been utilized where appropriate, with construction differences being indicated with the suffix "a" or with different numerals. While the suffix "a" indicates different construction, example material for such constructions is the same as used in the above embodiments for the same numerals without the suffix "a". An alterable material 40 has been formed over first features 14 and second features 22 of the Fig. 7 construction. Alterable material 40 interacts selectively or uniformly with certain materials with which it forms an interface. Alterable material 40 may be cast onto a pre-patterned surface (for example as shown) and may be conformal or non-conformal. Casting via spin-casting, dip-casting, drop-casting, or similar, are examples. The alterable material will be altered by material from the spaced second features to form altered material on sidewalls of the spaced second features. The altered material may form spontaneously upon deposition of the alterable material, or be subsequently activated, for example via thermal, photonic, electronic, ionic (including acid-based chemistry) treatments, by way of examples only. Accordingly, the altering may occur during deposition and/or after deposition. In one embodiment, no altering occurs until after completion of the deposition of the alterable material. Further, the altering may be self-limiting in the case of a limiting reagent or equilibrium conditions, or kinetically arrested if reactants are in excess. Alterable material 40 may have a planar outermost surface or a non-planar outermost surface, with an example planar outermost surface 42 being depicted in Fig. 12. Alterable material may or may not be homogenous.

Material 40 may be similar to a class of materials available from Clariant International, Ltd. as so-called "AZ R" materials, such as the materials designated as AZ R200™, AZ R500™ and AZ R600™. The "AZ R" materials contain organic compositions which cross-link upon exposure to acid released from chemically-amplified resist. Accordingly for example, such materials constitute an example alterable material where material of spaced second features 20 comprises chemically-amplified resist. More specifically, an "AZ R" material may be coated across photoresist, and subsequently the resist may

be baked at a temperature of from about 100°C to about 120°C to diffuse acid from the resist into the alterable material to form chemical cross-links within regions of the alterable material proximate the resist. Portions of the material adjacent the resist are thus selectively hardened relative to other portions of
5 material that are not sufficiently proximate the resist. The material may then be exposed to conditions which selectively remove the non-hardened portions relative to the hardened portions. Such removal may be accomplished utilizing, for example, 10% isopropyl alcohol in deionized water, or a solution marketed as "SOLUTION C™" by Clariant International, Ltd. Processes utilizing the
10 "AZ R" materials are sometimes considered examples of RELACS (Resolution Enhancement Lithography Assisted by Chemical Shrink) processes.

A challenge with the "AZ R" materials is that they can be similar enough in composition to photoresist that it may be difficult to selectively remove photoresist relative to hardened "AZ R" materials. In one embodiment, alterable
15 material 40 may be similar to the "AZ R" materials in that it may comprise a similar or identical organic composition which is altered (for instance, forms cross-links) upon exposure to one or more substances (for instance, acid) released from materials 14, 20, 18 over which material 40 lies when the substrate is baked. However, unlike "AZ R" materials, material 40 may also
20 contain one or more components disbursed in the organic composition which are provided to chemically change material 40 relative to material of features 14 and 22 (for example, photoresist and/or other organic material in embodiments where material of features 14 and 22 may be selectively removed relative to material 40). Components which may be disbursed in an organic composition of
25 a material 40 may include one or more of titanium, carbon, fluorine, bromine, silicon and germanium. Any carbon disbursed in the organic composition may be part of a carbide compound so it is chemically different from bulk carbon of the organic composition. Any fluorine and/or bromine may be, for example, comprised of hydrofluoric acid and hydrobromic acid. In some embodiments,
30 the components disbursed in an organic composition of a material 40 include one or more inorganic components, such as, for example, silicon, germanium, metals (for instance, titanium, tungsten, platinum, etc.) and/or metal-containing compounds (for instance, metal nitride, metal silicide, etc.). The component of material 40 that is similar to "AZ R" materials may be referred to as an "AZ R"-

type composition. Accordingly, in some embodiments, alterable material 40 may be considered to have one or more inorganic components disbursed in an organic "AZ R"-type composition. However, alterable material 40 may comprise other than organic and other than "AZ R"-type compositions, for
5 example as explained below.

Referring to Fig. 13, substrate 10a has been subjected to conditions which cause inter-diffusion of materials 20 and 40 and inter-diffusion of materials 14 and 40. Some substance of materials 20 and 14 alters material 40 to form altered material 44 proximate spaced first features 14 and spaced second features 22.
10 Accordingly, the alterable material is capable of being altered with material from the first and second features to form altered material on sidewalls of the first and second features, for example as shown in Fig. 13. In one embodiment, the altering alters a portion of the alterable material 40 adjacent each of spaced first features 14 and spaced second features 22 to form altered material 44 while
15 leaving portions of the alterable material distal from the spaced first and second features unaltered. Fig. 13 also depicts an embodiment wherein altered material 44 has been formed elevationally over first features 14 and over second features 22. Altered material 44 may or may not be homogenous.

In some embodiments, material of first features 14 and second features 22
20 comprises chemically-amplified photoresist, and the substance from such photoresist which imparts the altering to material 44 is acid. The acid may be caused to be released from photoresist by baking semiconductor substrate 10a at a temperature of at least about 100°C. The acid forms cross-links with "AZ R"-type composition of material 40. The amount of cross-linking, and the distance
25 that the cross-linking spreads from features 14 and 22 may be adjusted by modifying one or both of bake time and bake temperature.

As an additional example where materials 14, 18 and 20 comprise silicon, an example alterable material 40 is a refractory metal, such as titanium, to result in a reaction ultimately to form the altered material to comprise a metal silicide.
30 Such by way of example only is shown and described in U.S. Patent Application Publication No. US2007/0049030. Additional alterable materials depending at least in part upon the composition of the spaced second features are also of course contemplated, and whether existing or yet-to-be developed.

Referring to Fig. 14, and in one embodiment, un-reacted distal portions of material 40 (not shown) which were not altered to form material 44 have been removed, for example by etching, selectively relative to altered material 44. Suitable chemistries and conditions may be selected by the artisan depending upon composition of materials 40, 44 and 12. For example with respect to the "AZ R"-type compositions referred to above, such removal may be accomplished utilizing isopropyl alcohol and/or SOLUTION C™ as discussed above. Where material 40 may comprise additional components disbursed in an "AZ R"-type composition, such components may simply rinse away as the non-altered regions of material 40 are removed. Alternately, such additional components may be removed with solvents which remove the additional components. For instance, if silicon dioxide is utilized as a component of material 40, hydrofluoric acid may be utilized during removal of the non-altered regions of material 40 to ensure that the silicon dioxide of the non-altered regions is removed in addition to the "AZ R"-type composition of the non-altered regions.

Referring to Fig. 15, altered material 44 has been anisotropically etched to form spacers 35.

Referring to Fig. 16, first features 16 and second features 22 have been removed from the substrate, forming a mask pattern 37 comprising altered material 44.

Referring to Fig. 17, substrate 10a has been processed through mask pattern 37. The example processing depicted in Fig. 17 is that of ion implantation, forming implanting regions 46.

Additional embodiments of methods of fabricating a substrate are next described with reference to Figs. 18-27 with respect to a substrate fragment 10b. Like numerals with respect to the above-described embodiments are utilized where appropriate, with differences in construction being indicated with the suffix "b" or with different numerals. While the suffix "b" indicates different construction, example material for such constructions may be the same as used in the above embodiments for the same numerals without the suffix "b". Fig. 18 depicts alternate processing to that of Fig. 3, and wherein an alterable material 40b has been formed over spaced first features 14.

Referring to Fig. 19, alterable material 40b has been altered with material from spaced first features 14 to form altered material 44b on sidewalls of spaced first features 14. Processing may be as described above, or otherwise, with respect to alterable material 40 and altered material 44.

5 Referring to Fig. 20, those portions of alterable material 40b (not shown) which were not altered have been removed from substrate 10b.

Referring to Fig. 21, a first material 20b has been deposited over altered material 44b, and is of some different composition from that of altered material 44b.

10 Referring to Fig. 22, only a portion of first material 20b has been removed to expose altered material 44b and form spaced first material 20b.

Referring to Fig. 23, altered material 44b (not shown) has been etched from between spaced first material 20b and spaced first features 14.

Referring to Fig. 24, width of spaced first material 20b has been laterally 15 trimmed, and spaced second features 22b have been formed.

In one embodiment, anisotropically etched spacers of some different composition from that of the spaced first features and from that of the spaced first material are formed on sidewalls of the spaced first features and on sidewalls of the spaced first material. For example, Fig. 25 depicts deposition 20 of spacer-forming layer 28, and Fig. 26 depicts etching thereof to form spacers 30.

Referring to Fig. 27, spaced first features 14 (not shown) and spaced first material 20b (not shown) have been removed from the substrate, thereby forming a mask pattern 32 comprising anisotropically etched spacers 30. 25 Substrate 12 would be processed through mask pattern 32, for example using any technique as described above.

Alternate embodiments to that depicted by Figs. 20-27 are also contemplated. For example, material 40b of Fig. 19 might be processed such that only a portion thereof is removed to expose second altered material 44b and 30 form spaced alterable material as opposed to deposition of material 20b and removing a portion thereof. For example, material 40b of Fig. 19 could be removed to directly produce the construction of Fig. 22 wherein material 20b is substituted by material 40b. After forming such spaced alterable material, altered material 44b would be etched from between the spaced alterable material

and third features would be formed which comprise the spaced alterable material, with the third features being spaced from the second features. For example, the construction of Fig. 23 could be formed wherein material 20b is substituted by spaced alterable material 4b after material 44 of Fig. 21 has been removed. Processing could then proceed as shown and described with reference to Figs. 24-27.

Additional embodiments are next described with reference to Figs. 28-32. Fig. 28 depicts alternate processing to that of Fig. 25 with respect to a substrate fragment 10c. Like numerals from the above-described embodiments have been utilized where appropriate, with construction differences being indicated with the suffix "d" or with different numerals. While the suffix "d" indicates different construction, example material for such constructions is the same as used in the above embodiments for the same numerals without the suffix "d". Prior to the processing of Fig. 28, the processing of Figs. 18-24 has occurred wherein material 40b of Fig. 18 may be considered as a first alterable material which was formed over spaced first features 14, and which was altered with material from spaced first features 14 to form a first altered material 44b on sidewalls of spaced first features 14. First material 20b was deposited over first altered material 44b. Only a portion of first material 20b was subsequently removed to expose first altered material 44b and form spaced material 20b. First altered material was etched from between spaced first material 20b and spaced first features 14. Width of spaced first material 20b was laterally trimmed, and spaced second features 22b have been formed. Alternately, unaltered of the alterable material may be used in place of the first material, as described above.

Referring to Fig. 28, a second alterable material 60 has been deposited over spaced first features 14 and over the spaced first material 20b. Composition and attributes of second alterable material 60 are the same as that described above for alterable material 40 and depending at least in part on composition of spaced first features 14 and spaced second features 22b.

Referring to Fig. 29, second alterable material 60 has been altered with material from spaced first features 14 and with material from spaced first material/second spaced features 22c to form second altered material 62 on

sidewalls of spaced first features 14 and on sidewalls of spaced first material/second spaced features 22c.

Referring to Fig. 30, unaltered second alterable material 60 (not shown) has been removed from the substrate selectively relative to second altered
5 material 62.

Referring to Fig. 31, second altered material 62 has been anisotropically etched to form spacers 30c.

Referring to Fig. 32, first features 14 (not shown) and first material/spaced second features 22b (not shown) have been removed from the
10 substrate, thereby forming a mask pattern 49 comprising second altered material 62. Substrate 12 would be processed through mask pattern 49, for example using any technique as described above.

CLAIMS:

1. A method of fabricating a substrate, comprising:

forming spaced first features and spaced second features over a substrate, the first and second features alternating with one another and being spaced
5 relative one another;

laterally trimming width of the spaced second features to a greater degree than any lateral trimming of width of the spaced first features while laterally trimming width of the spaced second features;

after the laterally trimming, forming spacers on sidewalls of the spaced
10 first features and on sidewalls of the spaced second features, the spacers being of some different composition from that of the spaced first features and from that of the spaced second features;

after forming the spacers, removing the spaced first features and the spaced second features from the substrate; and

15 after the removing of the spaced first and second features from the substrate, processing the substrate through a mask pattern comprising the spacers.

2. The method of claim 1 wherein the forming of the spaced second features comprises etching material from which the spaced second feature are
20 formed while no etch mask is received anywhere over the substrate.

3. The method of claim 1 wherein the spaced second features are formed to comprise second material received over first material, the first and second materials being of some different composition.

4. The method of claim 1 wherein forming the spacers comprises
25 deposition of a spacer-forming layer followed by maskless anisotropic etching thereof.

5. The method of claim 1 wherein forming the spacers comprises depositing an alterable material over the spaced first features and the spaced second features and altering the alterable material with material from the spaced
30 first features and with material from the spaced second features to form altered material which comprises the spacers.

6. The method of claim 1 wherein no lateral width trimming of the spaced first features occurs during the laterally trimming of width of the spaced second features.

7. The method of claim 1 wherein the laterally trimming of width of
5 the spaced second features comprises etching; and

further comprising treating outermost surfaces of the spaced first features to provide resistance of the spaced first features to said etching.

8. The method of claim 7 wherein no lateral width trimming of the spaced first features occurs during said etching to laterally trim width of the
10 spaced second features.

9. A method of fabricating a substrate, comprising:

forming spaced first features over a substrate;

depositing a first material over the spaced first features which is of some different composition from that of the spaced first features;

15 depositing a second material over the first material, the second material being of some different composition from that of the first material;

removing only a portion of the second material to expose the first material and form spaced second material received over the first material;

after forming the spaced second material, etching the first material from
20 between the spaced second material and forming spaced second features which comprise spaced second material received over first material, the second features being spaced from the first features;

after the etching of the first material, laterally trimming width of the spaced second features;

25 after the laterally trimming, forming spacers on sidewalls of the spaced first features and on sidewalls of the spaced second features, the spacers being of some different composition from that of the spaced first features and from that of the spaced second features;

after forming the spacers, removing the first features and the second
30 features from the substrate; and

after the removing of the first features and the second features from the substrate, processing the substrate through a mask pattern comprising the

spacers.

10. The method of claim 9 wherein the second material has a planar outermost surface prior to any removing of the second material.

11. The method of claim 9 wherein forming the spacers comprises
5 deposition of a spacer-forming layer followed by maskless anisotropic etching thereof.

12. The method of claim 9 wherein forming the spacers comprises depositing an alterable material over the spaced first features and the spaced second features and altering the alterable material with material from the spaced
10 first features and with material from the spaced second features to form altered material which comprises the spacers.

13. The method of claim 9 wherein the spacers of the mask pattern have at least two different thicknesses.

14. The method of claim 9 wherein the spacers of the mask pattern
15 comprise alternating first and second pairs of immediately adjacent spacers, the spacers of the first pair having a first common thickness and the spacers of the second pair having a second common thickness, the first and second thicknesses being different.

15. A method of fabricating a substrate, comprising:
20 forming spaced first features over a substrate;

depositing a first material over the spaced first features which is of some different composition from that of the spaced first features;

depositing a second material over the first material, the second material being of some different composition from that of the first material;
25 removing only a portion of the second material to expose the first material and form spaced second material received over the first material;

after forming the spaced second material, etching the first material from between the spaced second material and forming spaced second features which comprise spaced second material received over first material, the second
30 features being spaced from the first features;

after the etching of the first material, laterally trimming width of the spaced second features;

after the laterally trimming, depositing an alterable material over the spaced first features and the spaced second features and altering the alterable
5 material with material from the spaced first features and with material from the spaced second features to form altered material on sidewalls of the spaced first features and on sidewalls of the spaced second features;

after the altering, removing the first features and the second features from the substrate; and

10 after removing the first features and the second features from the substrate, processing the substrate through a mask pattern comprising the altered material.

16. The method of claim 15 wherein the spaced first features comprise photoresist.

15 17. The method of claim 15 wherein forming the spaced first features comprises forming spaced mask features followed by laterally trimming the spaced mask features to reduce their respective widths.

18. The method of claim 17 wherein the mask pattern has pitch of about one fourth that of the spaced mask features.

20 19. The method of claim 15 wherein the second material has a planar outermost surface prior to any removing of the second material.

20. The method of claim 15 wherein the altering occurs during deposition of the alterable material.

21. The method of claim 15 wherein the altering occurs after
25 completion of the deposition of the alterable material.

22. The method of claim 15 wherein no altering occurs until after completion of the deposition of the alterable material.

23. The method of claim 15 wherein the altering alters a portion of the alterable material adjacent each of the spaced first features and the spaced

second features to form the altered material while leaving portions of the alterable material distal the spaced first features and the spaced second features unaltered.

24. The method of claim 23 comprising etching the distal portions
5 away selectively relative to the altered material.

25. The method of claim 15 wherein the altering forms altered material over tops of the spaced first features and over tops of the spaced second features.

26. The method of claim 15 wherein the alterable material has a planar
10 outermost surface.

27. A method of fabricating a substrate, comprising:

forming spaced first features over a substrate;

depositing an alterable material over the spaced first features and altering the alterable material with material from the spaced first features to form altered
15 material on sidewalls of the spaced first features;

depositing a first material over the altered material which is of some different composition from that of the altered material;

removing only a portion of the first material to expose the altered material and form spaced first material;

20 after forming the spaced first material, etching the altered material from between the spaced first material and the spaced first features;

after the etching of the altered material, laterally trimming width of the spaced first material;

after the laterally trimming, forming anisotropically etched spacers on
25 sidewalls of the spaced first features and on sidewalls of the spaced first material, the anisotropically etched spacers being of some different composition from that of the spaced first features and from that of the spaced first material;

after forming the anisotropically etched spacers, removing the spaced first features and the spaced first material from the substrate; and

30 after removing the spaced first features and the spaced first material from the substrate, processing the substrate through a mask pattern comprising the

anisotropically etched spacers.

28. The method of claim 27 wherein the first material is of the same composition as that of the spaced first features.

29. The method of claim 27 wherein the first material is of some
5 different composition from that of the spaced first features.

30. The method of claim 27 wherein the first material has a planar outermost surface prior to any removing of the first material.

31. The method of claim 27 wherein the spaced first features comprise photoresist and the alterable material comprises one or more inorganic
10 components dispersed in an organic composition that is cross-linkable upon exposure to acid, wherein the material from the spaced first features includes acid, and the altering the alterable material comprises forming cross-links within the organic composition upon exposure to the acid in the material from the spaced first features.

15 32. The method of claim 31 wherein the one or more inorganic components includes silicon.

33. The method of claim 31 wherein the one or more inorganic components includes metal.

34. A method of fabricating a substrate, comprising:
20 forming spaced first features over a substrate;
depositing an alterable material over the spaced first features and altering only some of the alterable material with material from the spaced first features to form altered material on sidewalls of the spaced first features and leave alterable material elevationally over and between the altered material;
25 after the alternating, removing only a portion of the alterable material to expose the altered material and form spaced alterable material;
after forming the spaced alterable material, etching the altered material from between the spaced alterable material and the spaced first features;
after the etching of the altered material, laterally trimming width of the

spaced alterable material;

after the laterally trimming, forming anisotropically etched spacers on sidewalls of the spaced first features and on sidewalls of the spaced alterable material, the anisotropically etched spacers being of some different composition from that of the spaced first features and from that of the spaced alterable material;

after forming the anisotropically etched spacers, removing the spaced first features and the spaced alterable material from the substrate; and

after removing the spaced first features and the spaced alterable material from the substrate, processing the substrate through a mask pattern comprising the anisotropically etched spacers.

35. A method of fabricating a substrate, comprising:

forming spaced first features over a substrate;

depositing a first alterable material over the spaced first features and altering the first alterable material with material from the spaced first features to form first altered material on sidewalls of the spaced first features;

depositing a first material over the first altered material which is of some different composition from that of the first altered material;

removing only a portion of the first material to expose the first altered material and form spaced first material;

after forming the spaced first material, etching the first altered material from between the spaced first material and the spaced first features;

after the etching of the first altered material, laterally trimming width of the spaced first material;

after the laterally trimming, depositing a second alterable material over the spaced first features and the spaced first material and altering the second alterable material with material from the spaced first features and with material from the spaced first material to form second altered material on sidewalls of the spaced first features and on sidewalls of the spaced first material;

after forming the second altered material, removing the spaced first features and the spaced first material from the substrate; and

after the removing of the spaced first features and spaced first material from the substrate, processing the substrate through a mask pattern comprising

the second altered material.

36. The method of claim 35 wherein the first material has a planar outermost surface prior to any removing of the first material.

37. A method of fabricating a substrate, comprising:

5 forming spaced first features over a substrate;

depositing a first alterable material over the spaced first features and altering only some of the first alterable material with material from the spaced first features to form first altered material on sidewalls of the spaced first features and leave first alterable material elevationally over and between the

10 first altered material;

after the altering of the first alterable material, removing only a portion of the first alterable material to expose the first altered material and form spaced first alterable material;

after forming the spaced first alterable material, etching the first altered

15 material from between the spaced first alterable material and the spaced first features;

after the etching of the first altered material, laterally trimming width of the spaced first alterable material;

after the laterally trimming, depositing a second alterable material over

20 the spaced first features and the spaced first alterable material and altering the second alterable material with material from the spaced first features and with material from the spaced alterable material to form second altered material on sidewalls of the spaced first features and on sidewalls of the spaced alterable material;

25 after forming the second altered material, removing the spaced first features and the spaced first alterable material from the substrate; and

after the removing of the spaced first features and spaced first alterable material from the substrate, processing the substrate through a mask pattern comprising the second altered material.

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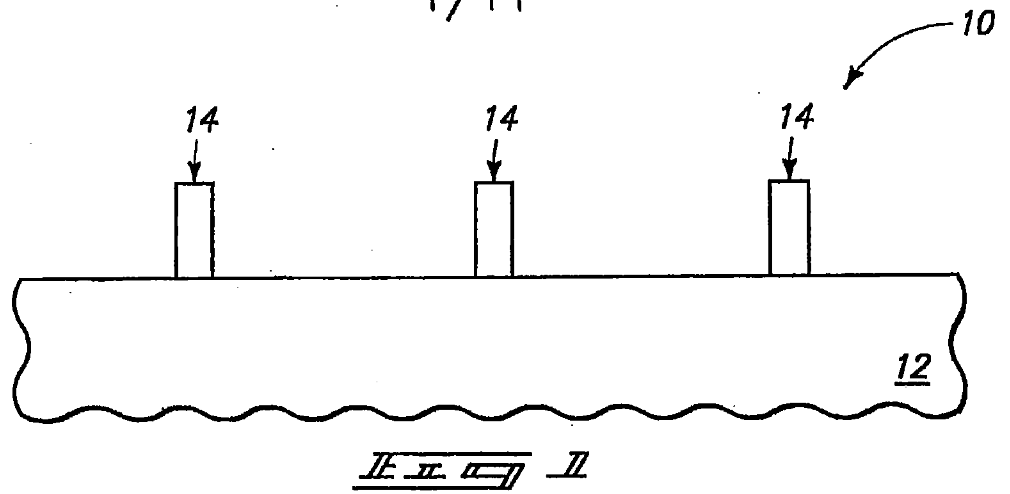

Fig 1

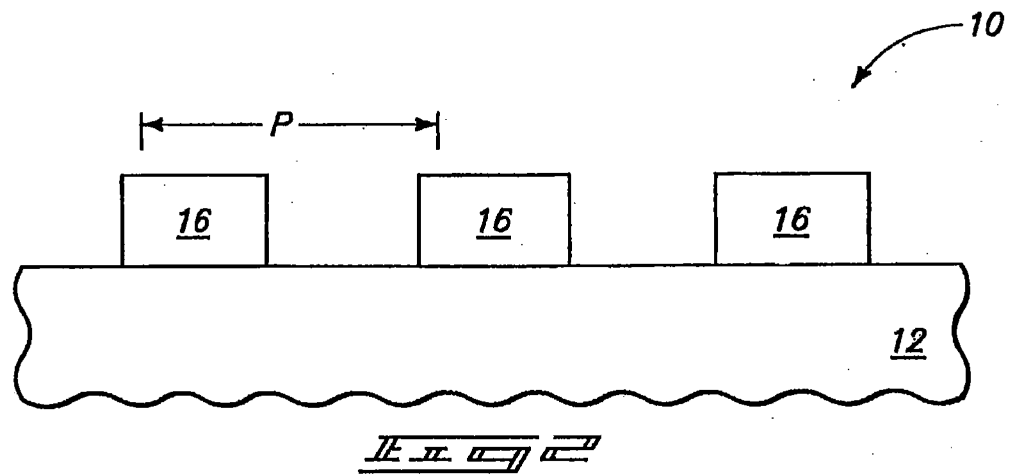

Fig 2

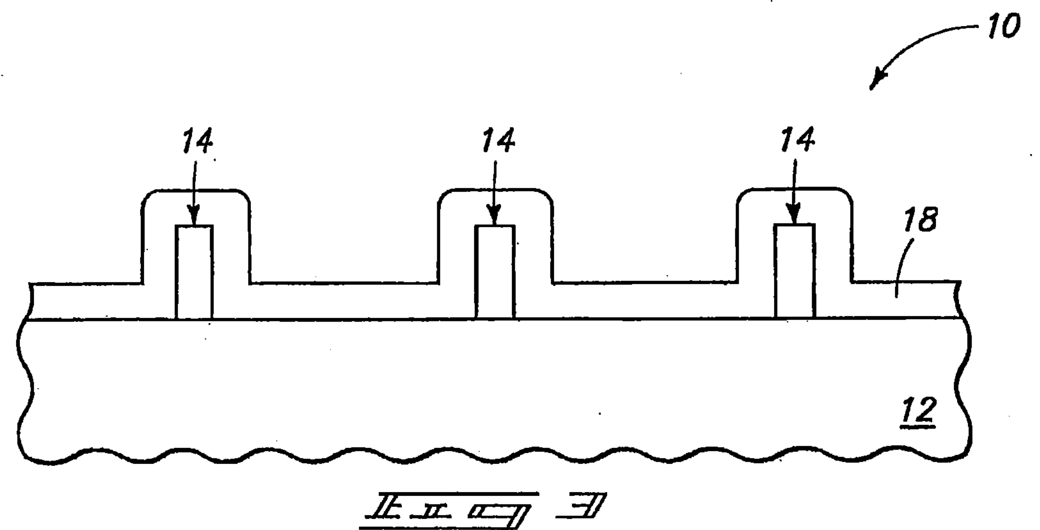

Fig 3

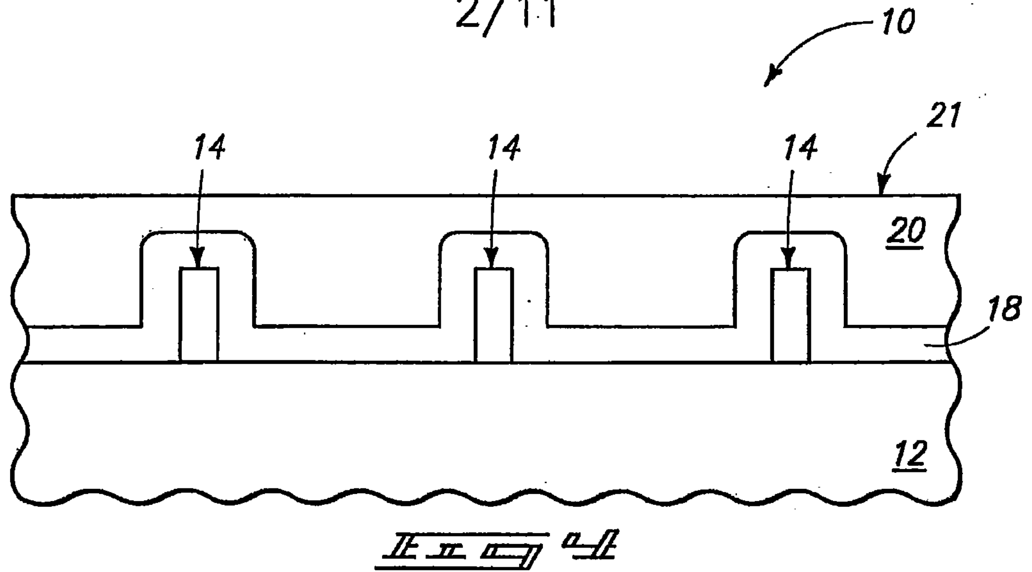

Fig 4

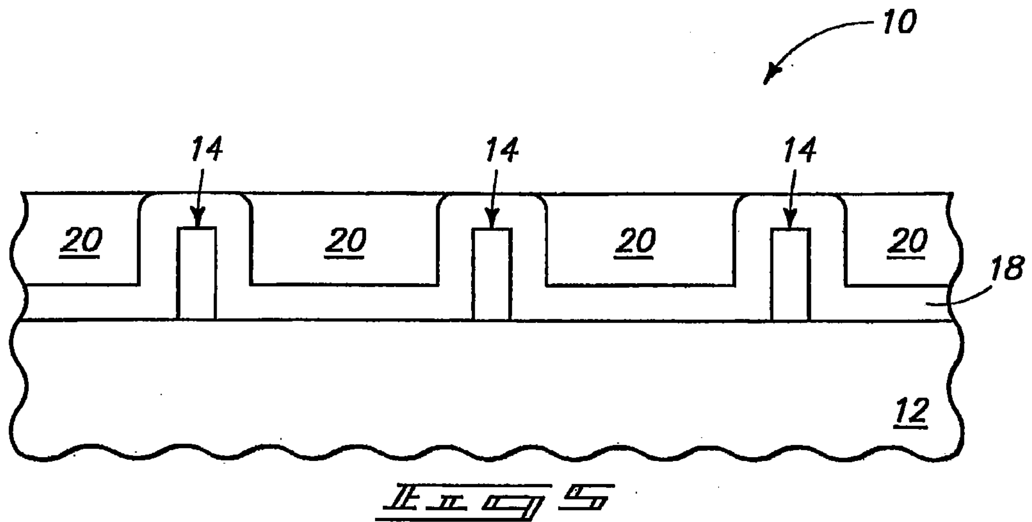

Fig 5

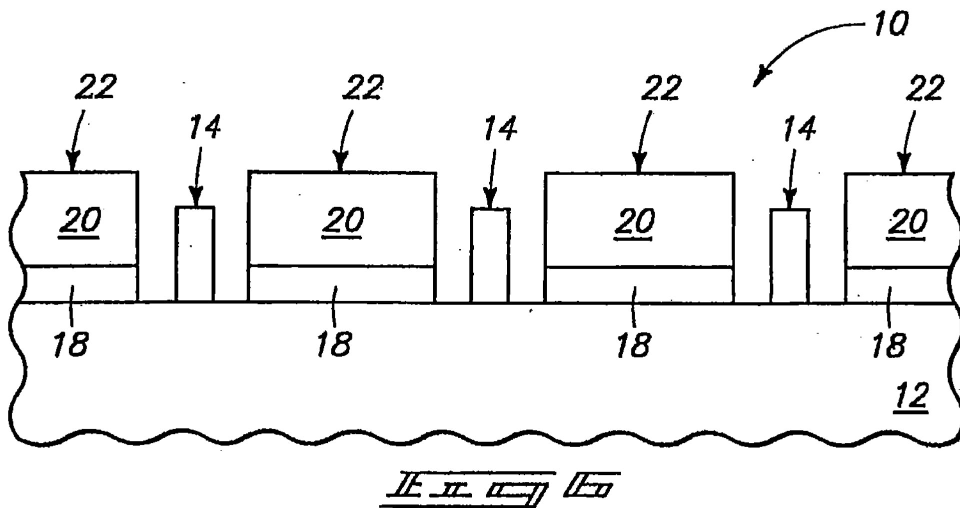

Fig 6

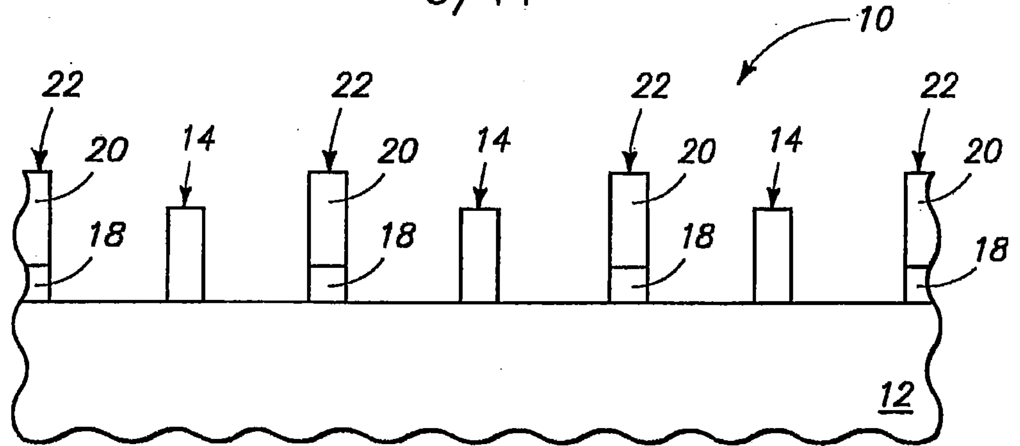

FIG 7

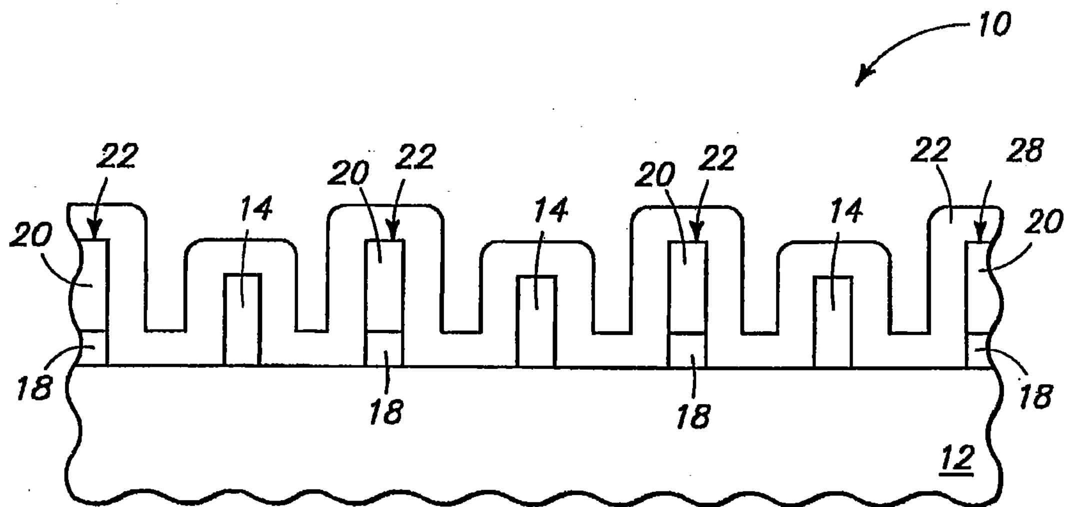

FIG 8

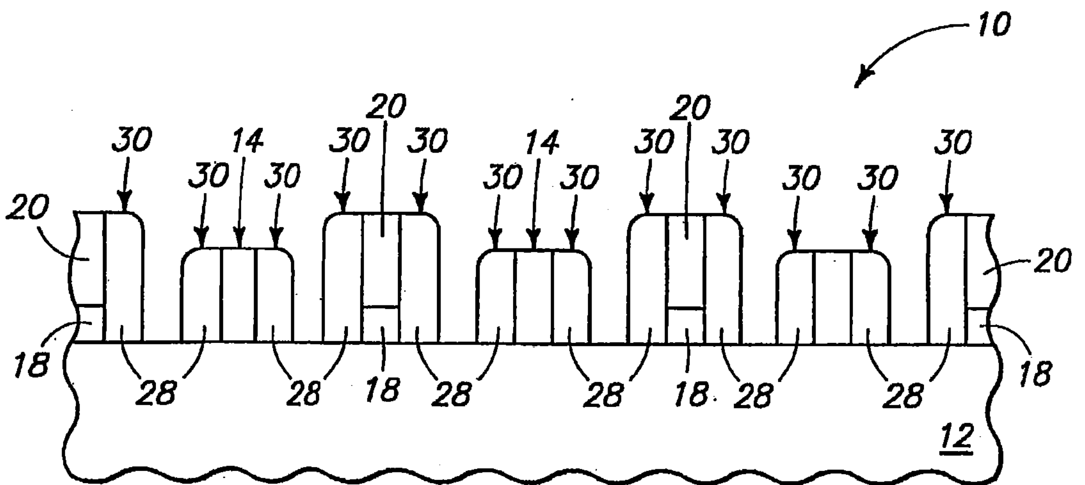

FIG 9

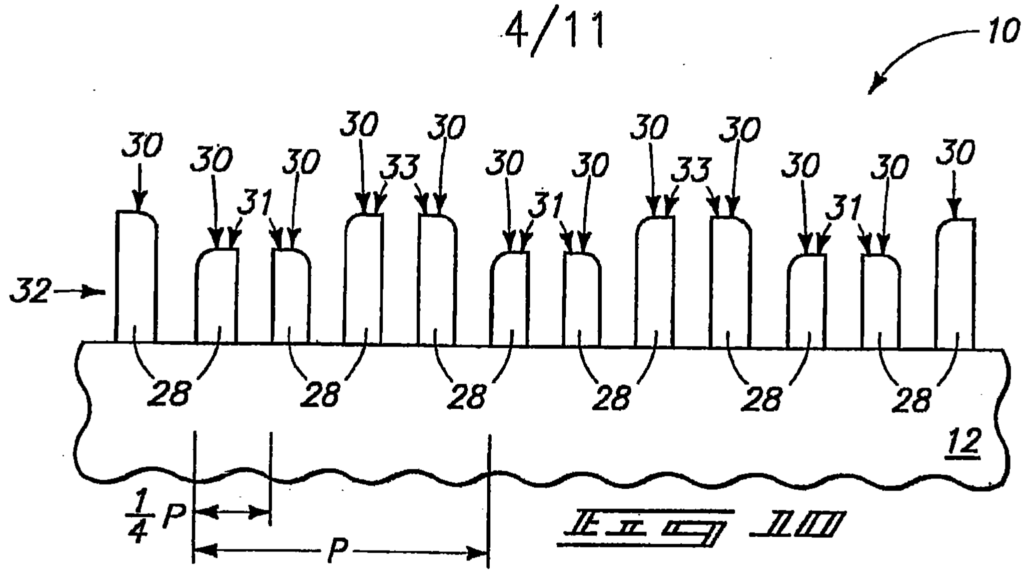
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Fig 10

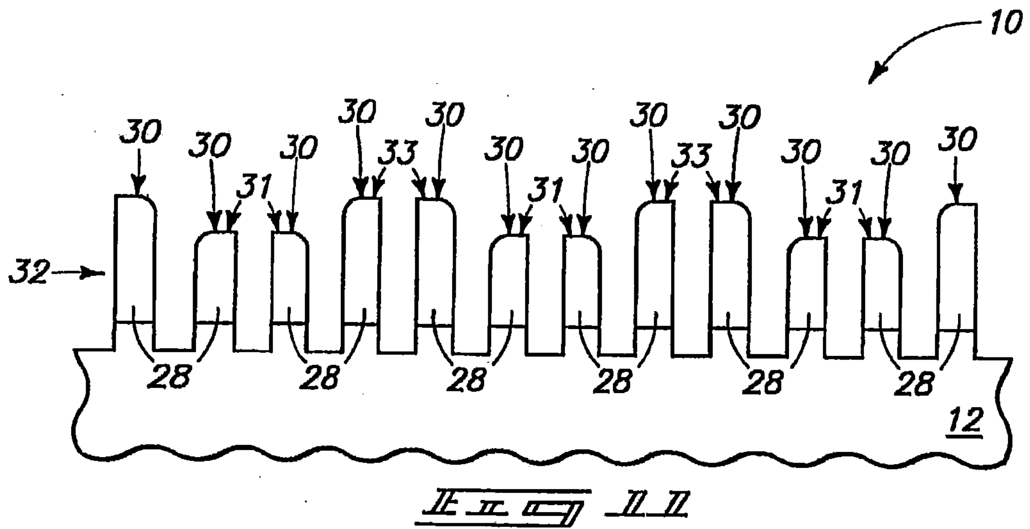
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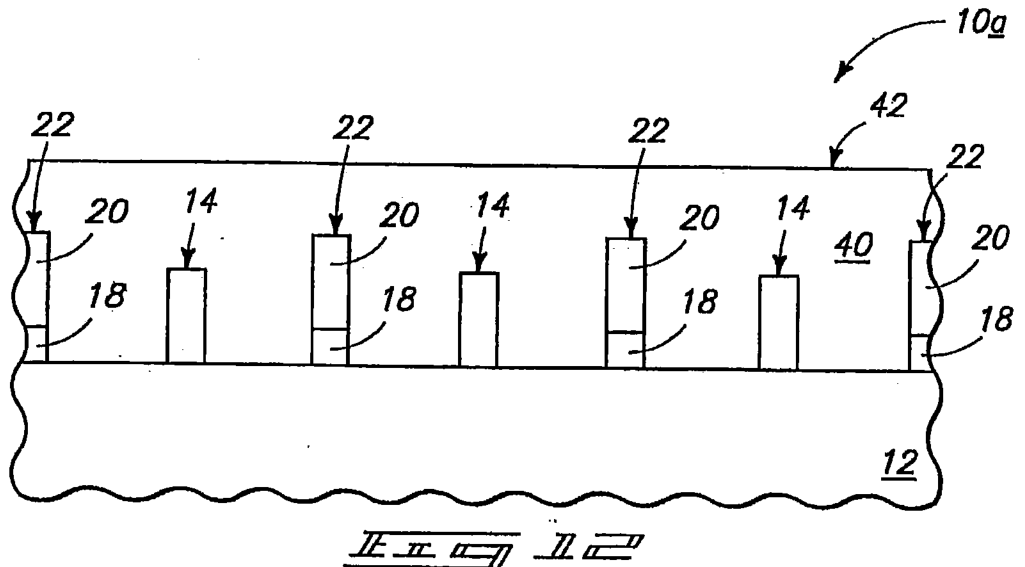
Fig 11


10a
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22
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Fig 12

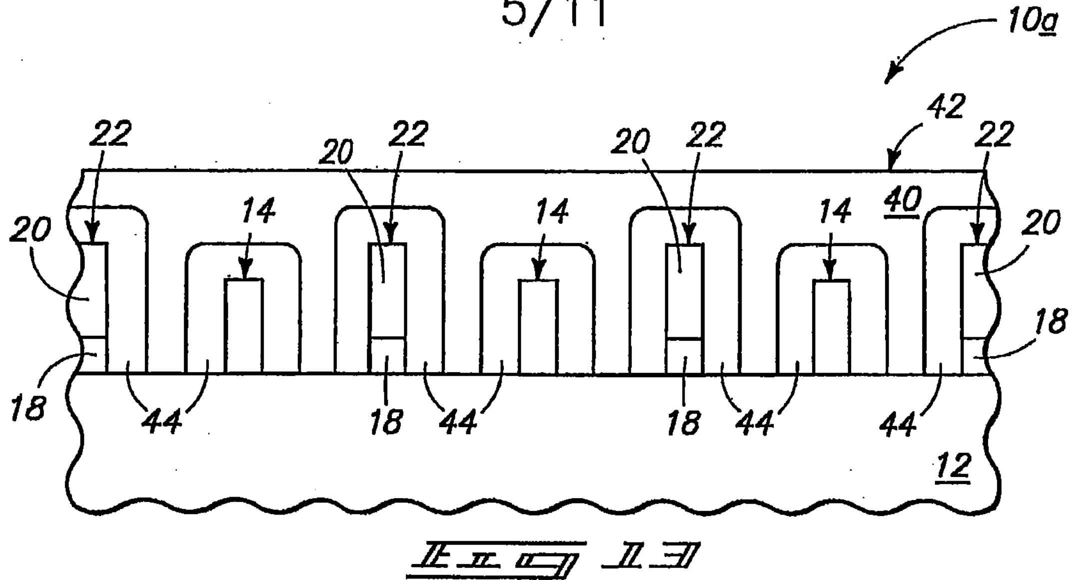

FIG 13

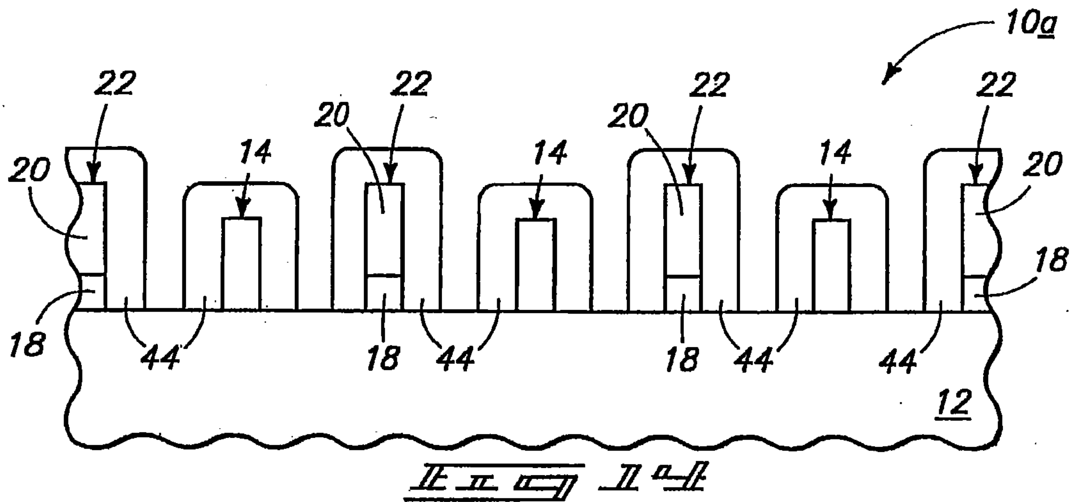

FIG 14

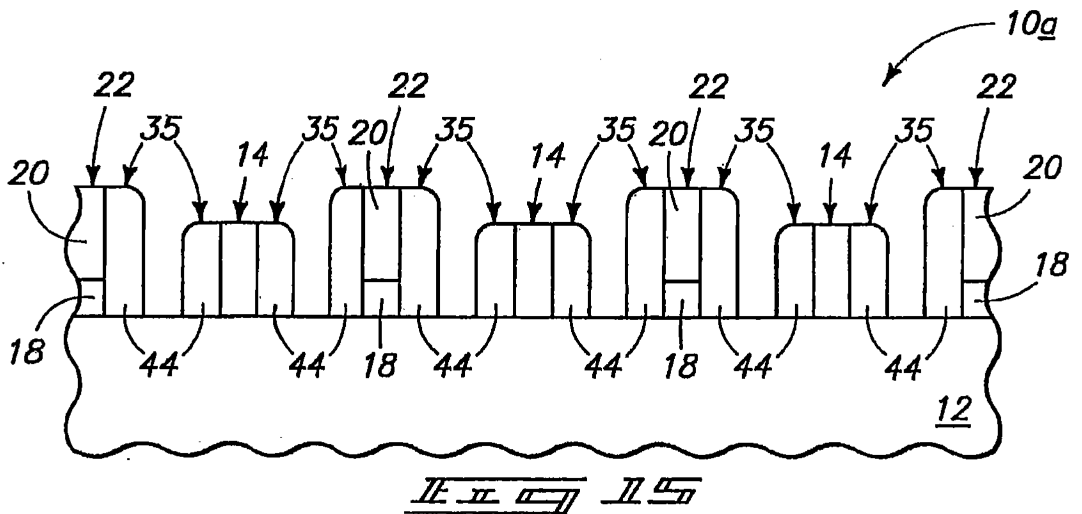

FIG 15

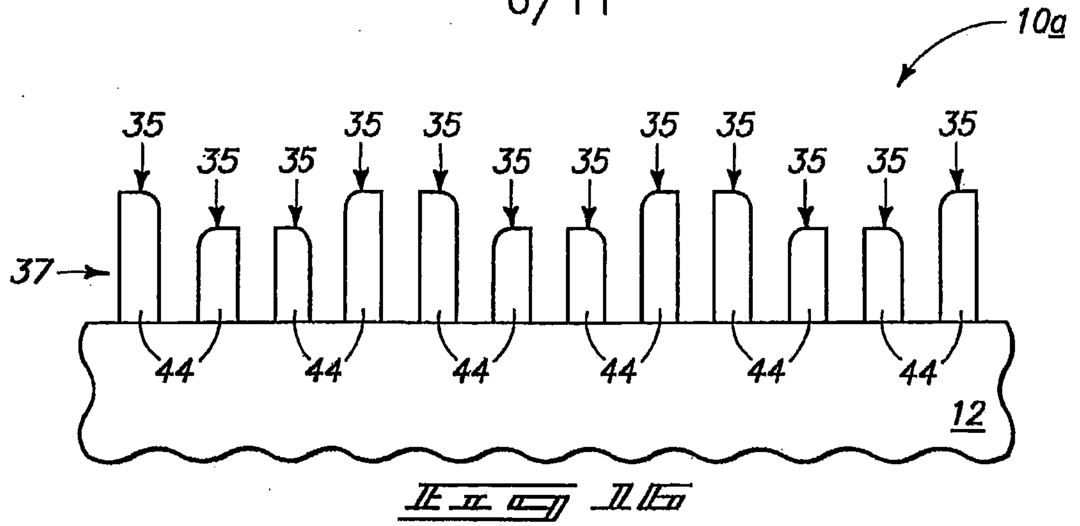

Fig 16

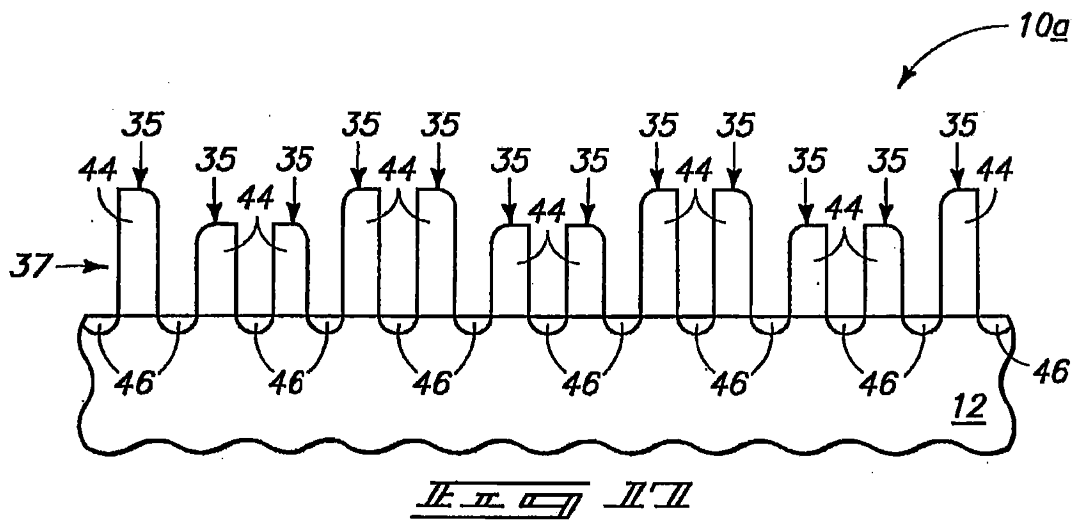

Fig 17

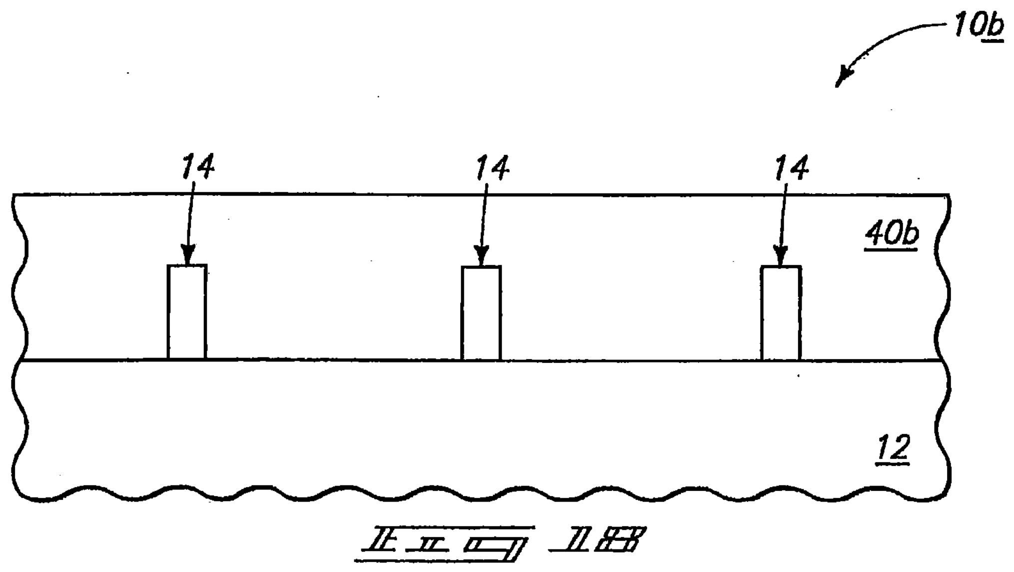

Fig 18

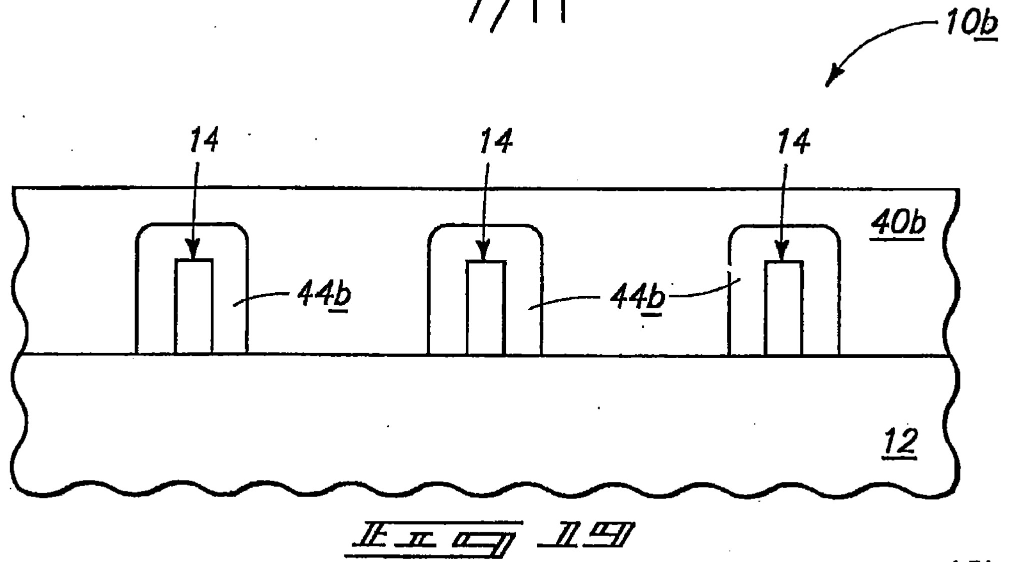

Fig 19

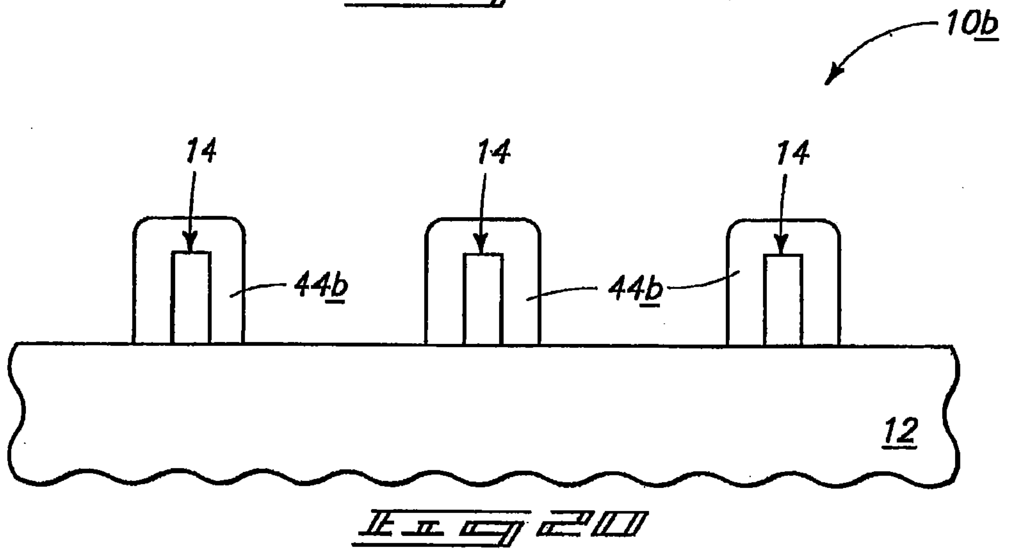

Fig 20

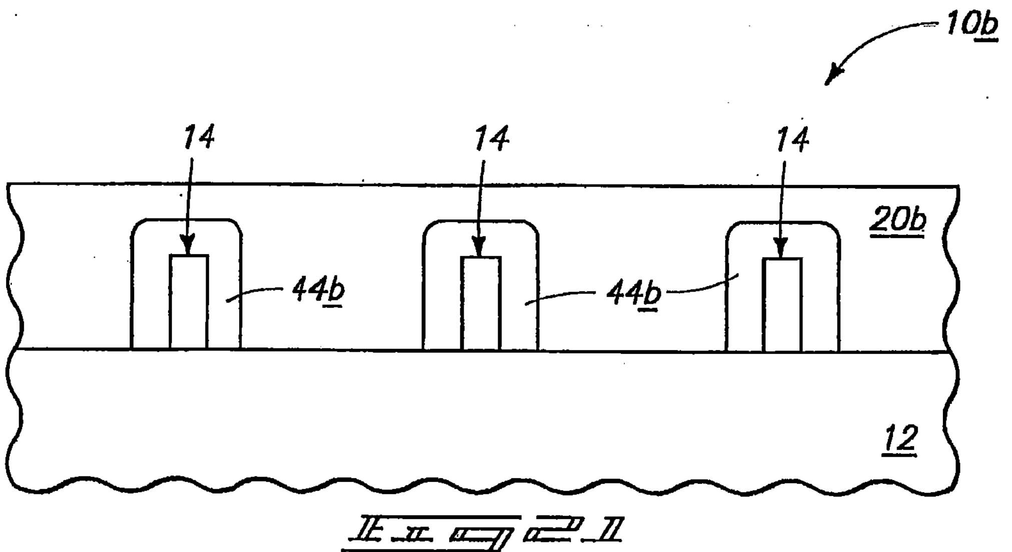

Fig 21

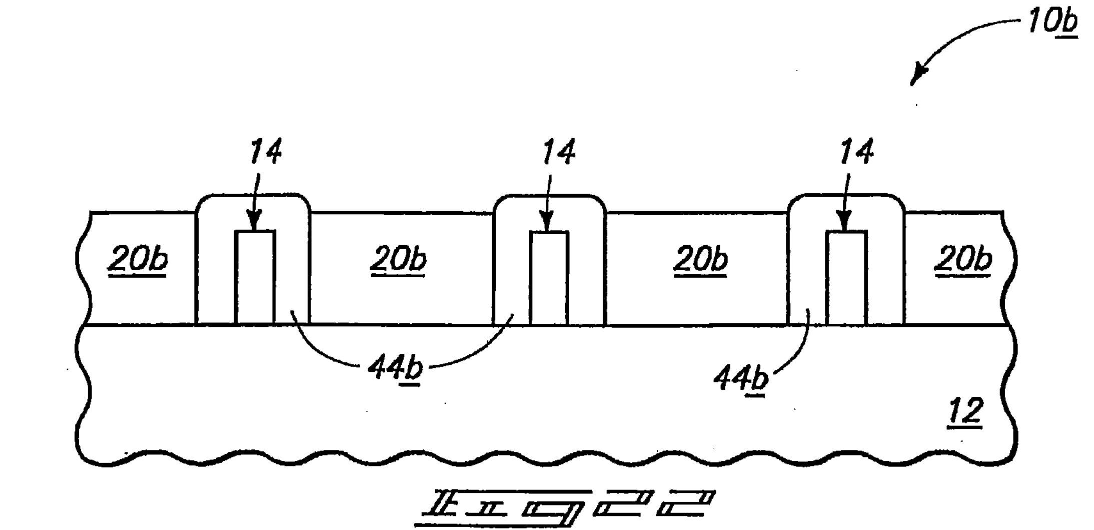

FIG 22

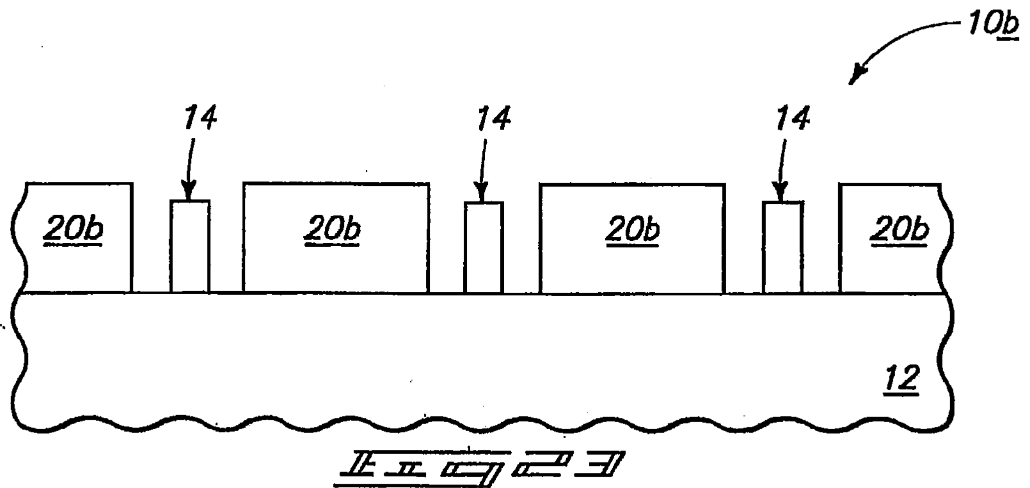

FIG 23

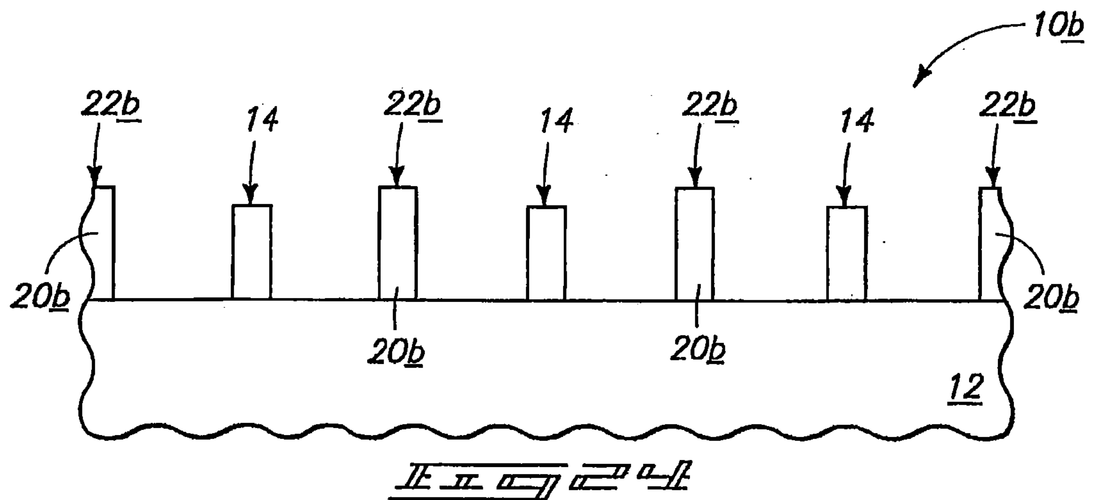

FIG 24

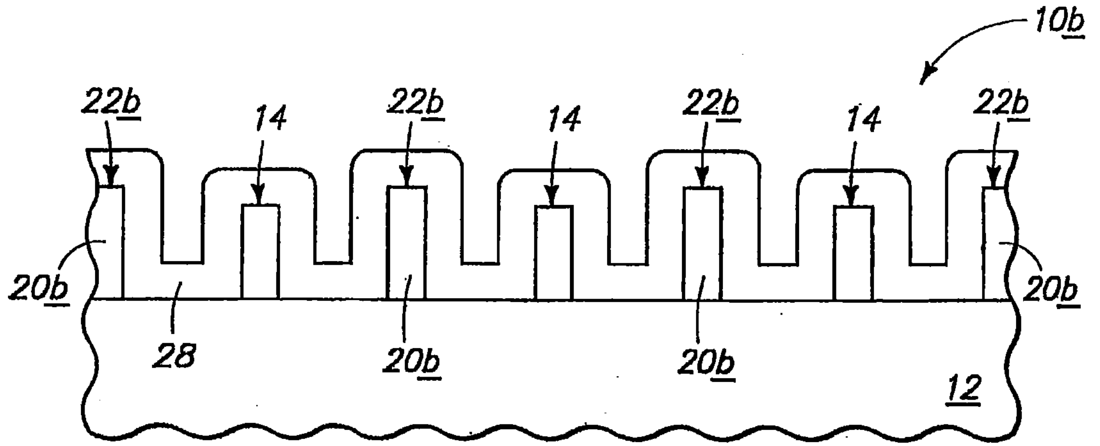

Fig 25

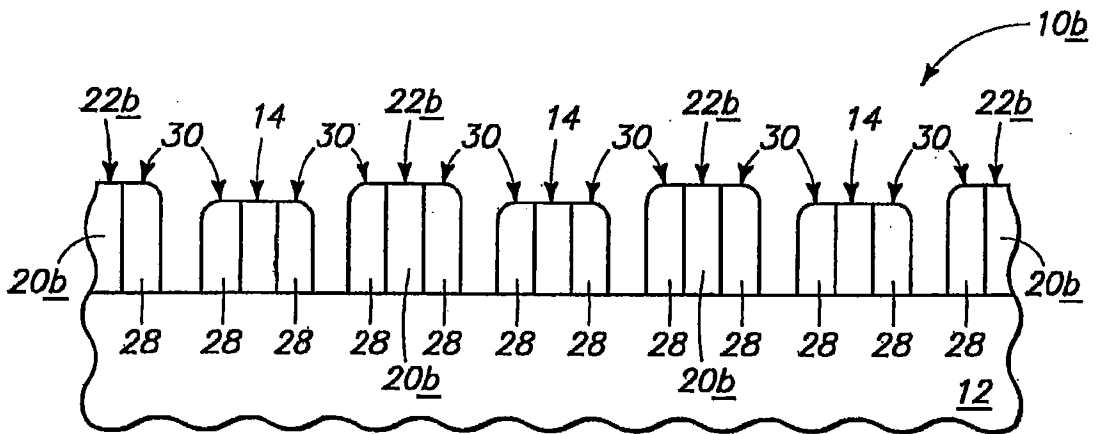

Fig 26

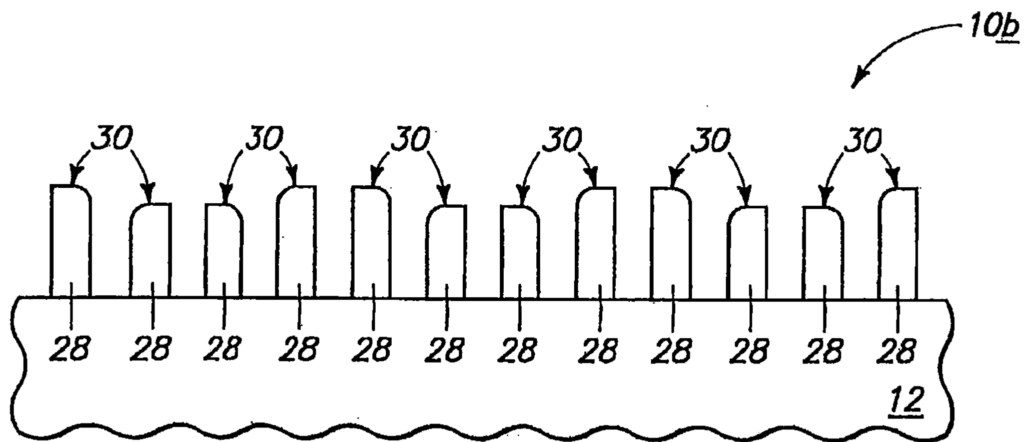

Fig 27

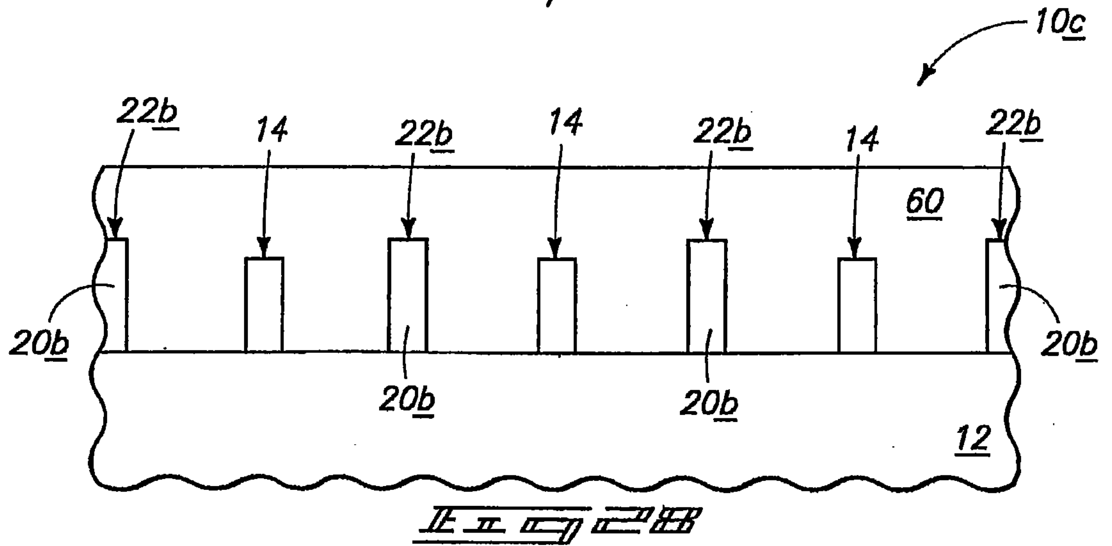

Fig 28

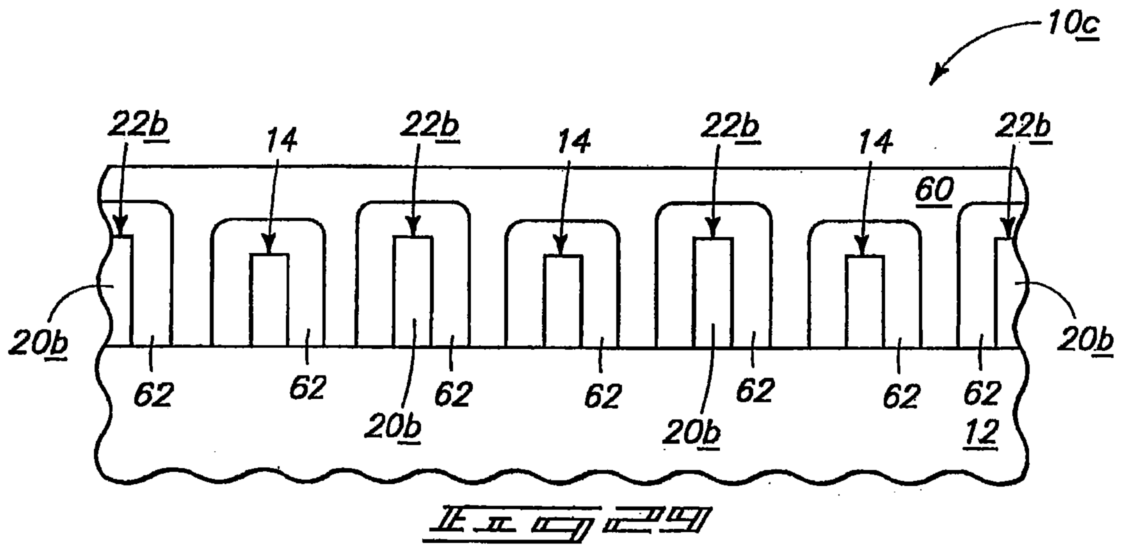

Fig 29

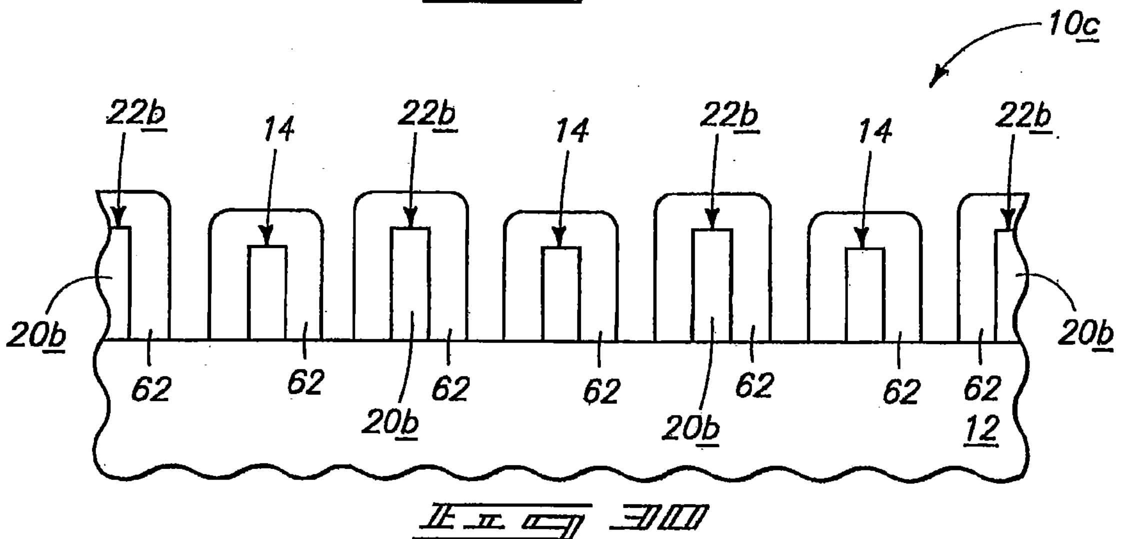

Fig 30

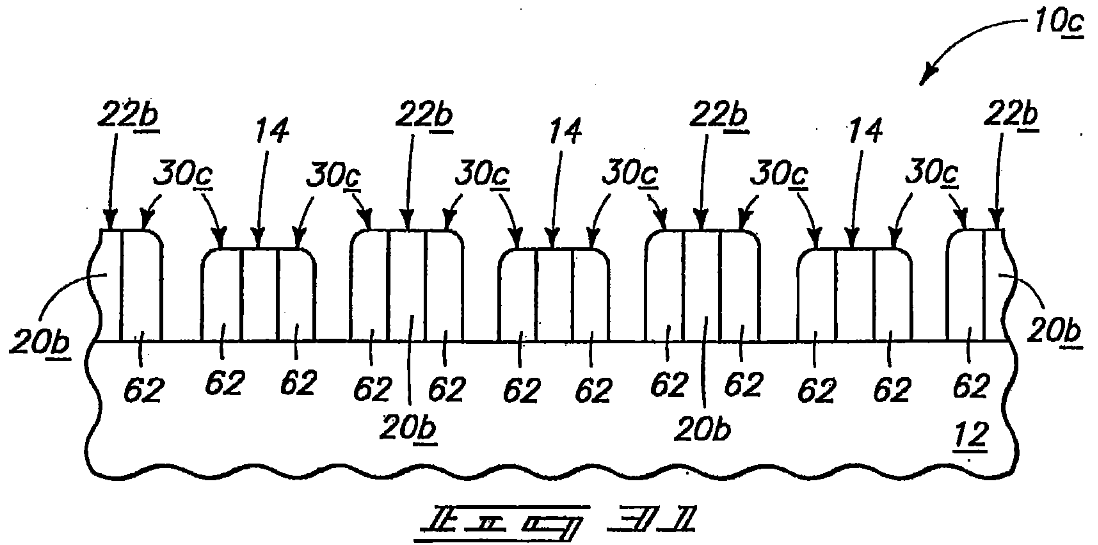

Fig 31

Fig 32