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(54) **Method of creating an alignment mark on a substrate and substrate.**

(57) A method of creating an alignment mark on a substrate includes forming a plurality of lines segmented into electrically conducting line segments and space segments thereby forming spaces between the lines to form a macroscopic structure in a first layer of the substrate, creating a plurality of electrically conducting trenches in a second layer of the substrate, and arranging the plurality of trenches to be in electrical contact with the line segments and arranging the plurality of trenches to overlap the space segments at least partially.

METHOD OF CREATING AN ALIGNMENT MARK ON A SUBSTRATE AND SUBSTRATE

Field

[0001] The invention relates to a method of creating an alignment mark on a substrate and a substrate formed by the method.

Background

[0002] In IC production lithography is used to produce multiple stacked and overlapping circuit patterns. The production of such overlapping circuit patterns includes exposing a layer of photo-resist on a wafer. By exposing a first layer of photo-resist to a first pattern followed by some additional process steps, a first pattern is created on the wafer. Likewise, a second pattern is created on the wafer after some intermediate process steps including applying a second layer of photo-resist. The second pattern should very accurately overlap the first pattern, because at specific positions the first and the second pattern will be electrically connected. These connections are provided by intermediate vias which are formed by exposing a third layer of photo-resist on the wafer (before applying and exposing the second layer). The vias itself need to be accurately positioned relative to the first and the second pattern.

[0003] In order to position the vias to the first layer and the second layer to the vias, alignment marks are used. A first alignment mark is formed by exposing the first layer of photo resist to an alignment mark pattern followed by some additional steps. Before exposing the third layer of photo-resist the position of the first alignment mark in the first layer is measured and the third layer is exposed in such a way that vias will be accurately positioned above the first pattern. Likewise, a second alignment mark is formed by exposing the third layer of photo resist to an alignment mark pattern followed by some additional steps. Before exposing the second layer of photo-resist, the position of the second alignment mark is measured. The second layer is then exposed in such a way that the second pattern will be accurately positioned above the vias.

[0004] Known alignment marks (or markers) are gratings comprising lines and spaces. The position of the alignment gratings is measured by alignment radiation. In order to assure that the alignment radiation does not activate photo-resist, the alignment radiation has a wavelength which differs considerably from the wavelength used in exposure radiation for exposing photo-resist. Roughly, the scale of the lines of the alignment mark is of the order of magnitude of the wavelength of the alignment radiation and the scale of the smallest features of the circuit patterns is of the scale of the wavelength of the exposure radiation. Because of

tolerances in the exposure process used to both expose the circuit patterns as the alignment patterns in one and the same layer of photo-resist, the difference in scale can cause an unwanted shift between the alignment mark and the circuit pattern in a certain photo-resist layer. To prevent this, the lines of the alignment marker are segmented to line segments and space segments so that the features actually exposed when exposing the alignment pattern are of a scale comparable to the scale of the smallest features of the circuit patterns.
Alignment performance depends on the contrast of the alignment markers which is based on differences in reflectance of alignment radiation between the lines (which are reflecting) and spaces (which are non-reflecting) of the alignment mark.

[0005] However, by segmenting the lines of the alignment marker, the contrast of the alignment marker is reduced. This can be understood by visualizing that the area of the reflecting lines is decreased by the area of the non-reflecting space segments.

[0006] It is an object of the invention to provide a method that increases the contrast of alignment markers.

[0007] According to an embodiment of the invention there is provided a method of creating an alignment mark on a substrate, comprising

- forming a plurality of lines segmented into electrically conducting line segments and space segments thereby forming spaces between the lines to form a macroscopic structure in a first layer of the substrate;
- creating a plurality of electrically conducting trenches in a second layer of the substrate;
- thereby arranging the plurality of trenches to be in electrical contact with the line segments and arranging the plurality of trenches to overlap the space segments at least partially.

[0008] Because the plurality of trenches at least partially overlaps the space segments and because the plurality of trenches is in electrical contact with the line segments, the overlapped part of the space segments contributes to reflecting alignment radiation.

[0009] According to an embodiment of the invention there is provided a substrate formed by the foregoing method.

DESCRIPTION

[0010] In a method according to an embodiment of the invention a first layer of photo-resist on a wafer is exposed to a pattern comprising plurality of lines segmented into line segments and space segments (figure 1) is exposed. In another step of the method, the first layer is exposed to a pattern of vias. In a further step of the method, the lines segments are filled with an electrically conducting material, such as aluminium (Al), silver (Ag) or tungsten (W). The lines, which are separated by spaces form a macroscopic structure of a scale which comparable to alignment radiation.

[0011] Then a second photo-resist layer is applied to the wafer. The photo-resist layer is exposed to a circuit pattern which is intended to form a so called metal-layer. The photo-resist layer is further exposed to a pattern of trenches (figure 2). The trenches are positioned to overlap the space segments at least partially (figures 3 and 4). In further steps of the method, the trenches are filled with an electrically conducting material, such as (Al), silver (Ag) or tungsten (W).

[0012] For forming another circuit pattern on the wafer, a further layer of photo-resist is applied to the wafer. Before exposing the further layer of photo-resist to the circuit pattern, the position of the alignment mark is determined by an alignment sensor. The alignment sensor uses alignment radiation to illuminate the alignment mark and detects the radiation reflected by the alignment mark. It uses the difference in reflection by the lines and spaces to determine the position.

[0013] In an embodiment of the invention, the lines form a periodic grating, and the alignment sensor comprises a detection grating and a radiation sensor. The radiation sensor is arranged to measure the amount of radiation reflected by the alignment mark on the wafer and transmitted through the detection grating. The alignment mark determines the position of the alignment mark by measuring the position of the wafer where the amount of radiation measured by the radiation sensor is maximal.

[0014] The invention encompasses multiple embodiments with different arrangements of the lines and trenches as indicated in figures 5 to 11, a to c.

[0015] In each figure, the a-figure relates to the pattern in the via-layer, the b-figure relates to the pattern in the metal layer and the c-figure relates to the combined pattern of the overlapping patterns.

[0016] In the embodiments of figure 5(a,b,c) the 4 sets of trenches are used. Each set comprises a plurality of trenches on a periodic grating. The sets are separated by separation spaces. Each set comprises two trenches (one on each end of the set) which are in a semi-dense configuration as they have a neighbouring trench on the one side and a separation space on the other side. Such semi-dense lines are subject to other process deviation when producing dense lines. As a result, a marker with more semi-dense lines gives a less good alignment accuracy.

[0017] In the embodiment of figures 6(a,b,c) also 4 sets of trenches are used each also have two semi-dense lines (one on each end of the set). The alignment marks suffer from the same process deviation as the alignment marks of the embodiment of figures 5(a,b,c).

[0018] The embodiment corresponding to figures 1, 2 and 3 as well as the embodiments corresponding to figures 7(a,b,c), 8(a,b,c), 9(a,b,c), 10(a,b,c) and 11(a,b,c) have the additional advantage over the embodiments of figures 5(a,b,c), 6(a,b,c) that the trenches are formed in only 1 set. The complete alignment mark only has 2 trenches (1 at each end) formed in a semi-dense configuration. Therefore the alignment marks according to the embodiment of figures 1, 2 and 3 as well as the embodiments corresponding to figures 7(a,b,c), 8(a,b,c), 9(a,b,c), 10(a,b,c) and 11(a,b,c) can be used to give more accurate alignment results.

[0019] The description above is intended to be illustrative, not limiting. Thus, it will be apparent to one skilled in the art that modifications may be made to the invention as described without departing from the scope of the clauses set out below. Other aspects of the invention are set out as in the following numbered clauses:

1. A method of creating an alignment mark on a substrate, comprising:

forming a plurality of lines segmented into electrically conducting line segments and space segments thereby forming spaces between the lines to form a macroscopic structure in a first layer of the substrate;

creating a plurality of electrically conducting trenches in a second layer of the substrate, wherein the plurality of trenches are in electrical contact with the line segments and are arranged to overlap the space segments at least partially.

2. A method according to clause 1, further comprising segmenting the plurality of lines in two directions.

3. A method according to clause 1 or 2, wherein the plurality of lines and the plurality of trenches are formed so that the plurality of trenches overlaps with the spaces between the lines at least partially.

4. A method according to clause 1 or 3, wherein the electrically conducting line segments or the trenches comprise at least one of aluminium, silver and tungsten.

5. A method according to one of clauses 1-4, comprising determining the position of the alignment mark based on macroscopic properties of the alignment mark including the position of the macroscopic structure.

6. A substrate formed in accordance with the method of any of clauses 1-5.

CONCLUSIE

1. Een lithografieinrichting omvattende:
een belichtinginrichting ingericht voor het leveren van een stralingsbundel;
een drager geconstrueerd voor het dragen van een patroneerinrichting, welke patroneerinrichting in staat is een patroon aan te brengen in een doorsnede van de stralingsbundel ter vorming van een gepatroneerde stralingsbundel;
een substraattafel geconstrueerd om een substraat te dragen; en
een projectieinrichting ingericht voor het projecteren van de gepatroneerde stralingsbundel op een doelgebied van het substraat, met het kenmerk, dat de substraattafel is ingericht voor het positioneren van het doelgebied van het substraat in een brandpuntsvlak van de projectieinrichting.

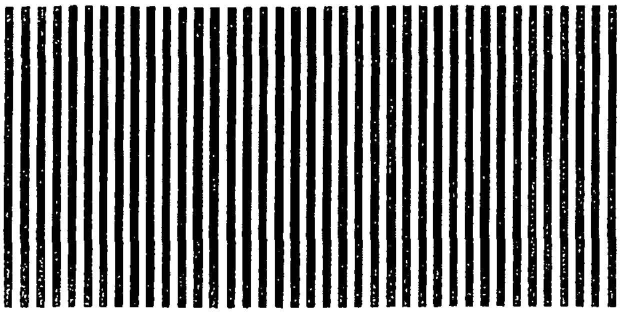

Figure 1

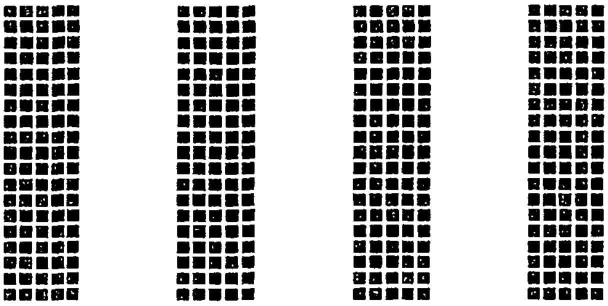

Figure 2

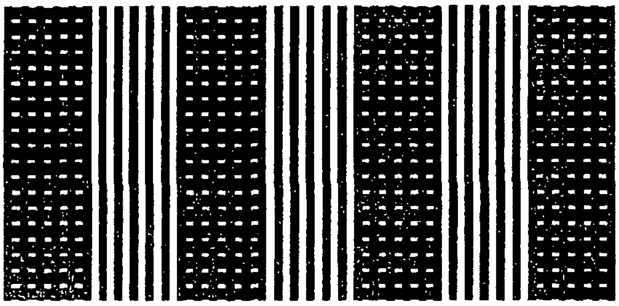

Figure 3

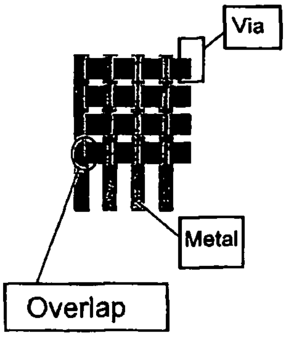

Figure 4

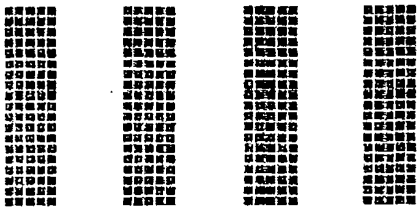

Figure 5a

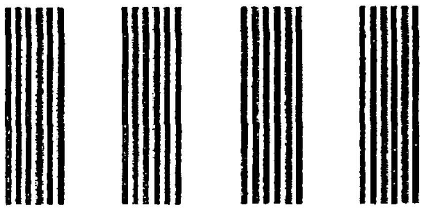

Figure 5b

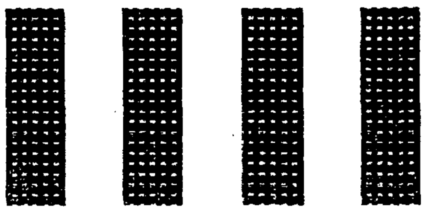

Figure 5c

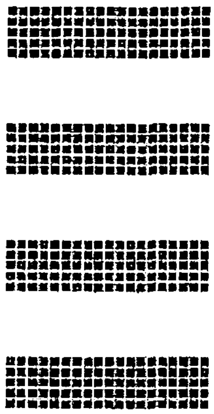

Figure 6a

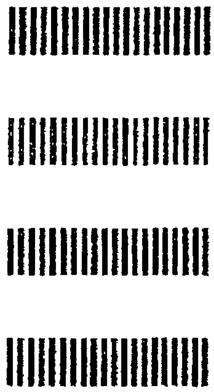

Figure 6b

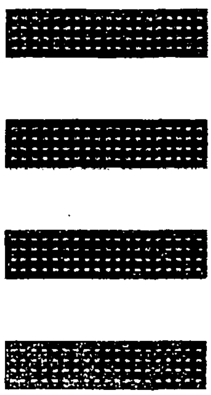

Figure 6c

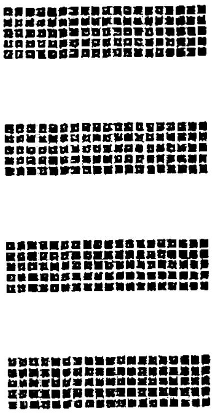

Fig 7a

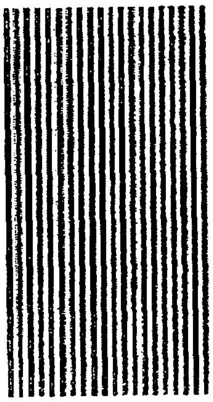

Fig 7b

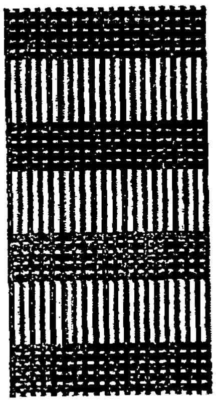

Fig 7c

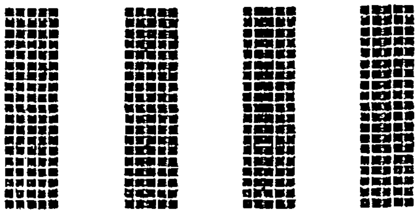

Fig 8a

Fig 8b

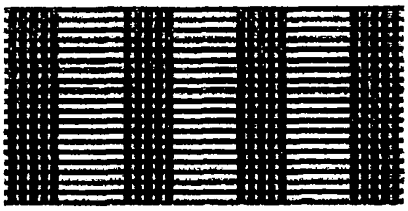

Fig 8c

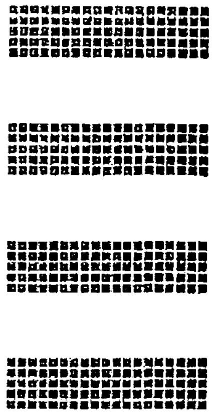

Fig 9a

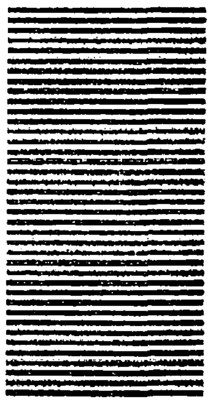

Fig 9b

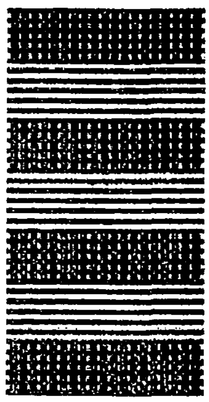

Fig 9c

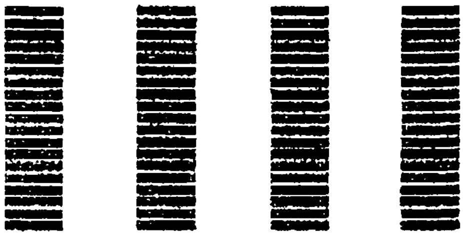

Fig 10a

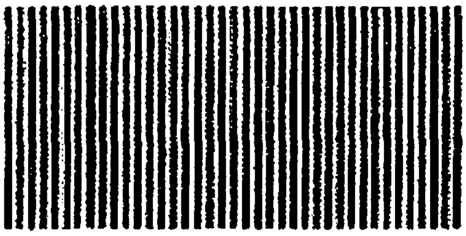

Fig 10 b

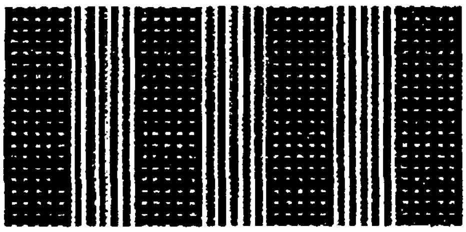

Fig 10c

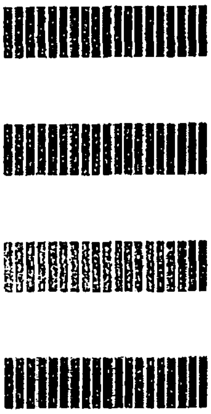

Fig 11a

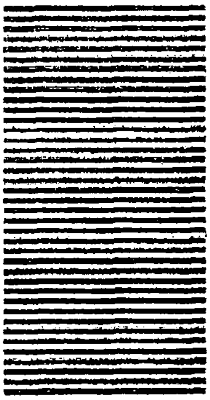

Fig 11b

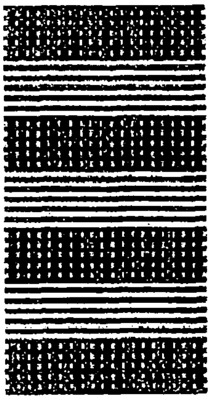

Fig 11c

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