Exhibit 12

Smith Deposition Exh. 10

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[54] **PROCESS FOR FORMING FINE PATTERNS IN A SEMICONDUCTOR DEVICE UTILIZING MULTIPLE PHOTOSENSITIVE FILM PATTERNS AND ORGANIC METAL-COUPLED MATERIAL**

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Related U.S. Application Data

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[30] **Foreign Application Priority Data**

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[51] **Int. Cl.**^{6} **G03F 7/38**; G03F 7/40

[52] **U.S. Cl.** **430/312**; 430/313

[58] **Field of Search** 430/312, 313, 430/314, 315, 316

[56] **References Cited**

U.S. PATENT DOCUMENTS

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[57] **ABSTRACT**

There are disclosed processes for forming fine patterns on a semiconductor substrate to a lesser degree than the resolving power of a step and repeat used, thereby improving the degree of integration of the semiconductor device. The process comprises the steps of: forming a first light-exposure mask and a second light-exposure mask with interlaced patterns selected from a plurality of fine patterns to be formed on a semiconductor substrate; coating an organic material layer on the semiconductor substrate; patterning the organic material layer by use of the first light-exposure mask, to form organic material layer patterns; forming a photosensitive film over the organic material layer patterns; and patterning the photosensitive film by use of the second light-exposure mask to form photosensitive film patterns, in such a way that each of photosensitive film patterns is interposed between two adjacent organic material layer patterns.

4 Claims, 15 Drawing Sheets

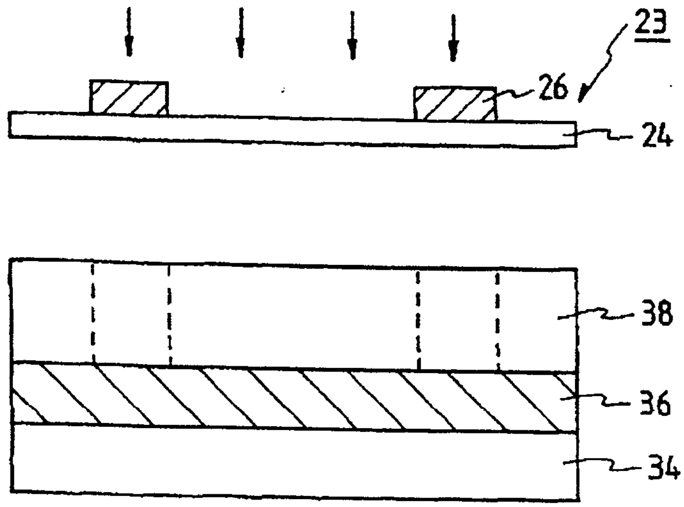

Fig.3C

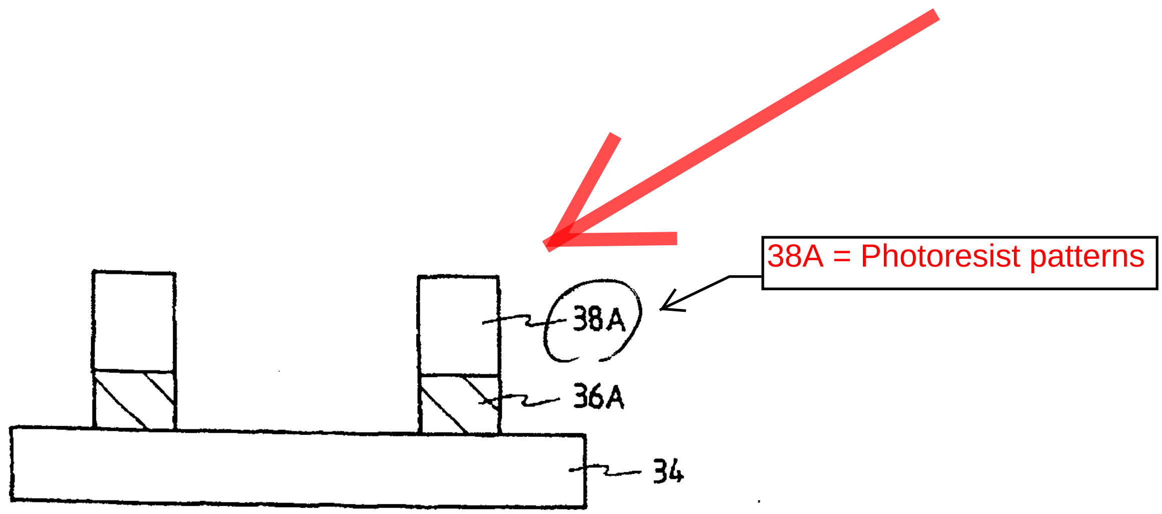

Fig.3D

Referring to FIGS. 3A and 3B, there are shown cross sections of light-exposure masks useful for a formation process for fine patterns on a semiconductor device, according to an embodiment of the present invention.

First, in FIG. 3A, there is shown a first light-exposure mask 23 comprising a first transparent substrate 24 on which first photointerceptive film patterns 26 are formed. While the first transparent substrate 24 is made of quartz, the first photointerceptive film patterns 26 are made of chrome.

In FIG. 3B, there is shown a second light-exposure mask 28 comprising a second transparent substrate 30 on which a second photointerceptive film pattern 32 is formed. Likewise, the second transparent substrate 30 and the second photointerceptive film pattern 32 are made of quartz and chrome, respectively. The second photointerceptive film pattern 32 is positioned at the central portion between the first photointerceptive film patterns 26 so as not to overlap the first photointerceptive film patterns 26 with the second photointerceptive film pattern 32. At the moment, the first and the second photointerceptive film patterns 26, 32 are aligned in such a way that the area of the first and the second transparent substrates 24, 30 through which a beam of light passes is as large as possible. In other words, a diffraction phenomenon of light must not occur by separating the first and the second patterns therefrom as far as possible.

With reference to FIGS. 3C through 3F, there is illustrated a process for forming fine patterns of a semiconductor device, according to a first embodiment on a the present invention.

First, as shown in FIG. 3C, a light is irradiated, as indicated by arrows, through the first light-exposure mask 23 of FIG. 3A into a semiconductor device comprising a lower layer 34 on which an organic material layer 36 and a first photosensitive film 38 are sequentially formed. The lower layer 34 is atop a semiconductor substrate (not shown). As a result, the first photosensitive film 38 is selectively exposed to the beam. In the meantime, the organic material layer 36 serves as a reflection-protective layer.

Thereafter, the light-exposed areas of the first photosensitive film 38 are removed, to form first photosensitive film patterns 38A through which the organic material layer 36 is partially exposed, as shown in FIG. 3D. Then, an etching step is undertaken to take off the organic material layer 36 exposed partially through the first photosensitive film patterns 38A, to form organic material layer patterns 36A which, in turn, expose the lower layer 34 selectively therethrough.

Following formation of the organic material layer patterns 36A, the first photosensitive film patterns 38A are eliminated, and a second photosensitive film 40 is coated entirely over the resulting structure, as shown in FIG. 3E. The second photosensitive film 40 is exposed to a beam of light irradiated as indicated by arrows. At this time, the second light-exposure mask 28 of FIG. 3B causes the second photosensitive film 40 to be exposed selectively.

Finally, for formation of a second photosensitive film pattern 40A, all areas of the second photosensitive film but the masked one are removed so as to bare the organic material layer pattern 40A completely, as shown in FIG. 3F. As mentioned above, the second photointerceptive film pattern 32 is positioned at the central portion between the first photointerceptive film patterns 26 so as not to overlap the first photointerceptive film patterns 26 with the second photointerceptive film pattern 32. Based on this position structure, the second photosensitive film pattern 40A is interposed between the organic material layer patterns 36A. All of the second photosensitive film patterns 40A and the organic material layer pattern 36A play a role of a mask for the fine pattern which exposes the lower layer 34 selectively therethrough.

Referring now FIGS. 4A through 4E, there is illustrated a step process for forming fine patterns on a semiconductor device, according to a second embodiment of the present invention.

First, as shown in FIG. 4A, a beam of light is irradiated, as indicated by arrows, through a first light-exposure mask 56 into a semiconductor device comprising a lower layer 42 on which a first photosensitive film 44, an intermediate layer 46, an organic material layer 48 and a second photosensitive film 50 are sequentially formed. As a result, the second photosensitive film 50 is selectively exposed to the beam. The lower layer 42 which is formed on a semiconductor substrate (not shown) is an object material of pattern. The intermediate film 46 is formed of a spin-on-glass (hereinafter referred to as "SOG") film. In the meantime, the organic material layer 48 serves as a reflection-protective layer. With regard to the first light-exposure mask 56, it comprises a first transparent substrate 52 made of quartz on which first photointerceptive film patterns 54 are formed of chrome.

Next, the exposed areas of the second photosensitive film 50 are eliminated, to form second photosensitive film patterns (not shown) through which the organic material layer 48 is selectively exposed, followed by selective removal of the exposed areas of the organic material layer 48. For this selective removal, an etching step is carried out. At least, organic material layer patterns 48A result. After formation of the organic material layer patterns 48A, the second photosensitive film patterns atop the organic material layer patterns 48A are eliminated, as shown in FIG. 4B. In turn, the organic material layer patterns 48A expose the intermediate layer 46 selectively therethrough.

Over the resulting structure, there is coated a third photosensitive film 58, that is then selectively exposed to a beam of light passing through a second light-exposure mask 64, as shown in FIG. 4C. The second light-exposure mask 64 is comprised of a second transparent substrate 62 made of quartz and second photointerceptive film patterns 64 atop the second transparent substrate 60. Each of the second photointerceptive film patterns 62, made of chrome, is positioned between two adjacent first photointerceptive film patterns 54 so that they might not overlap with each other. In order not to generate a diffraction phenomenon of light, the first photointerceptive film patterns 54 are separated from each other at a great distance relative to the wavelength of the beam. Likewise, in the second photointerceptive film patterns 62, the distance between two adjacent patterns is so very large relative to the wavelength of the beam as to prevent the diffraction phenomenon of light.

Thereafter, the exposed areas of the third photosensitive film 58 are eliminated, to form third photosensitive film patterns 58A, each of which is interposed between the organic material layer patterns 48A atop the intermediate layer 46, as shown in FIG. 4D. As a result, the third photosensitive film patterns 58A along with the organic material layer patterns 48A are used as a mask for the fine pattern through which the intermediate layer 46 is selectively exposed. An etching step is undertaken to remove the exposed areas of the intermediate layer 46, and thus, to form intermediate layer patterns 46A which, in turn, expose the first photosensitive film selectively therethrough.