

EXHIBIT F

(12) **United States Patent**
Gibson, Jr. et al.

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(45) **Date of Patent:** **Apr. 12, 2005**

(54) **SPLIT BARRIER LAYER INCLUDING NITROGEN-CONTAINING PORTION AND OXYGEN-CONTAINING PORTION**

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(73) Assignee: **Agere Systems Inc.**, Allentown, PA (US)

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(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 0 days.

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U.S. Appl. No. 10/038,352, filed Jan. 2, 2002.

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Primary Examiner—George Eckert
Assistant Examiner—Chris C. Chu

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(65) **Prior Publication Data**

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Related U.S. Application Data

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(51) **Int. Cl.**⁷ **H01L 23/48**; H01L 23/52; H01L 59/40

(52) **U.S. Cl.** **257/760**; 257/750; 257/751; 257/752; 257/758; 438/760; 174/258; 174/256; 428/428; 428/446; 428/447; 428/448

(58) **Field of Search** 257/750–760, 257/762; 438/760; 174/258, 256; 428/428, 446, 447, 448, 209, 210, 901

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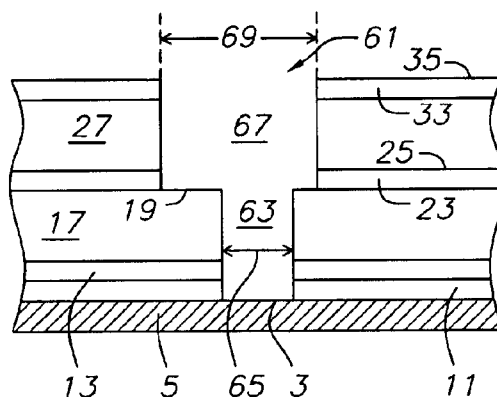
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(57) **ABSTRACT**

A split barrier layer enables copper interconnect wires to be used in conjunction with low-k dielectric films by preventing the diffusion of N—H base groups into photoresists where they can render the photoresist insoluble. The split barrier layer is disposed between the copper and the low-k dielectric and includes a nitrogen-containing, oxygen-free film which contacts the copper, and an oxygen-containing, nitrogen-free film which contacts the low-k dielectric film. The nitrogen-containing film prevents the formation of undesirable copper oxides, and the oxygen-containing film prevents the diffusion of N—H base groups into the low-k dielectric films. The oxygen-containing film may be an oxygen-doped silicon carbide film in an exemplary embodiment. In another embodiment, a film stack of low-k dielectric films includes an etch-stop layer and hardmask each formed of oxygen-doped silicon carbide. The hardmask and etch-stop layer enable the formation of a dual-damascene opening in the film stack, and the film structure of the present invention precludes N—H base groups from diffusing from the low-k dielectric films and neutralizing acid catalysts in the photoresist used to define the dual damascene opening.

13 Claims, 4 Drawing Sheets



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FIG. 1

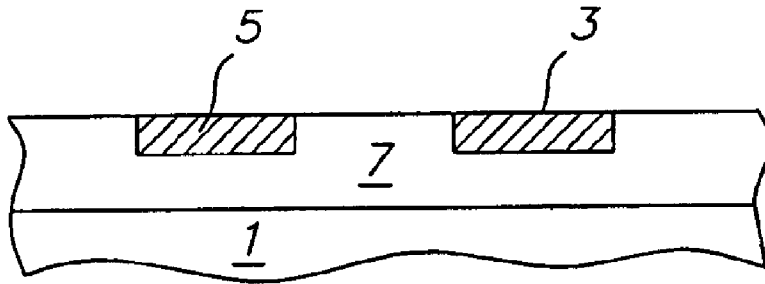


FIG. 2

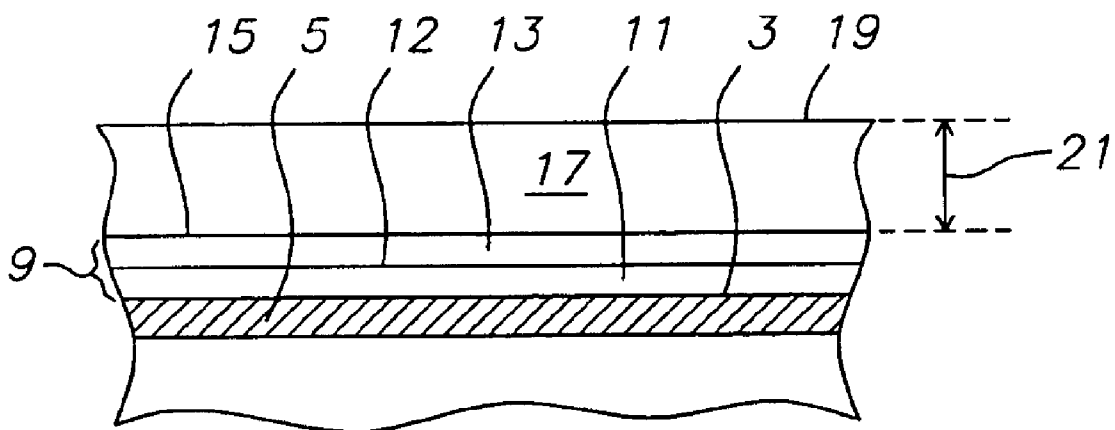


FIG. 3

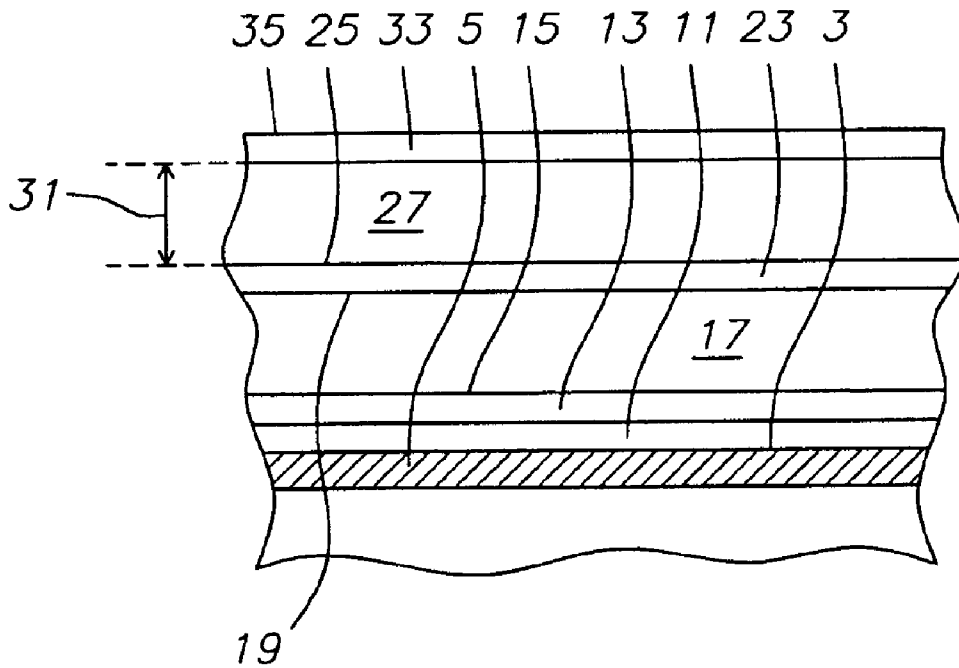
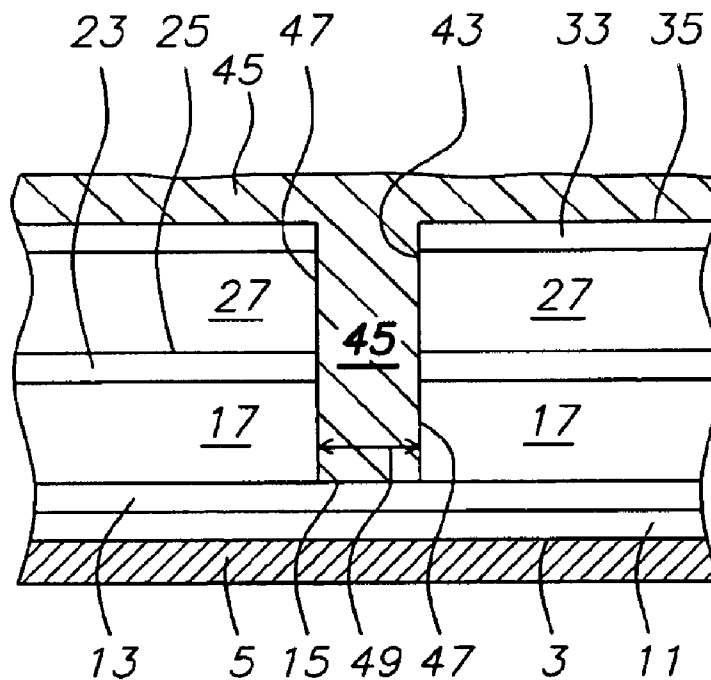


FIG. 4



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