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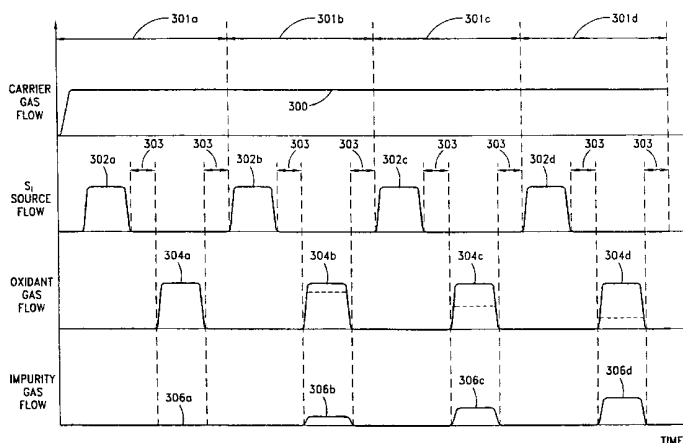
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[Continued on next page]

(54) Title: GRADED THIN FILMS



(57) Abstract: Thin films are formed by atomic layer deposition, whereby the composition of the film can be varied from monolayer to monolayer during cycles (301) or (450, 455, 460, 470) including alternating pulses of self-limiting chemistries. In the illustrated embodiments, varying amounts of impurity sources (306 or 460) are introduced during the cyclical process. A graded gate dielectric (72) is thereby provided, even for extremely thin layers. The gate dielectric (72) as thin as 2 nm can be varied from pure silicon oxide to oxynitride to silicon nitride. Similarly, the gate dielectric (72) can be varied from aluminum oxide to mixtures of aluminum oxide and a higher dielectric material (e.g., ZrO₂) to pure high k material and back to aluminum oxide. In another embodiment, metal nitride (432) (e.g., WN) is first formed as a barrier for lining dual damascene trenches and vias. During the alternating deposition process, copper can be introduced, e.g., in separate pulses, and the copper source pulses (460) can gradually increase in frequency, forming a graded transition region (434), until pure copper (436) is formed at the upper surface. Advantageously, graded compositions in these and a variety of other contexts help to avoid such problems as etch rate control, electromigration and non-ohmic electrical contact that can occur at sharp material interfaces.



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For two-letter codes and other abbreviations, refer to the "Guidance Notes on Codes and Abbreviations" appearing at the beginning of each regular issue of the PCT Gazette.

INTERNATIONAL SEARCH REPORT

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A. CLASSIFICATION OF SUBJECT MATTER
 IPC 7 C30B25/14 C23C16/44 H01L21/205

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC 7 C30B C23C H01L

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

EPO-Internal

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
P, X	WO 00 61833 A (SHERMAN ARTHUR) 19 October 2000 (2000-10-19) claims 1,20-22; example 3 ---	1-5, 7, 8, 25, 32, 34-36, 58
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X	US 5 294 286 A (NISHIZAWA JUNICHI ET AL) 15 March 1994 (1994-03-15) claims 1,3,5,6 ---	1-4
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Further documents are listed in the continuation of box C.

Patent family members are listed in annex.

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INTERNATIONAL SEARCH REPORT

Intern. Patent Application No

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C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	<p>BIKAS MAITI ET AL: "IMPROVED ULTRATHIN OXYNITRIDE FORMED BY THERMAL NITRIDATION AND LOW PRESSURE CHEMICAL VAPOR DEPOSITION PROCESS" APPLIED PHYSICS LETTERS, AMERICAN INSTITUTE OF PHYSICS, NEW YORK, US, vol. 61, no. 15, 12 October 1992 (1992-10-12), pages 1790-1792, XP000316470 ISSN: 0003-6951 the whole document</p>	34, 35
A	<p>DEL PRADO A ET AL: "Full composition range silicon oxynitride films deposited by ECR-PECVD at room temperature" THIN SOLID FILMS, ELSEVIER-SEQUOIA S.A. LAUSANNE, CH, vol. 343-344, April 1999 (1999-04), pages 437-440, XP004178394 ISSN: 0040-6090</p>	

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Information on patent family members

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