

(19) World Intellectual Property Organization
International Bureau



(43) International Publication Date
18 April 2002 (18.04.2002)

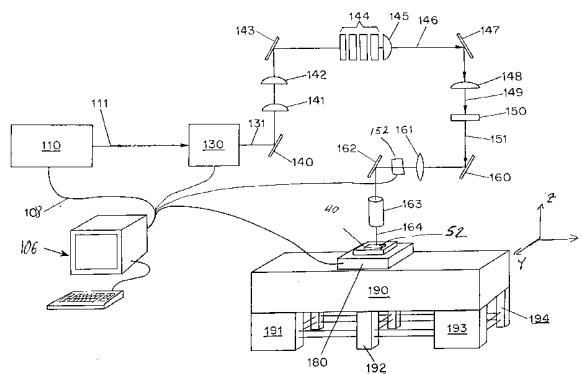
PCT

(10) International Publication Number
WO 02/031869 A3

- (51) International Patent Classification⁷: **H01L 21/768**
- (21) International Application Number: PCT/US01/31391
- (22) International Filing Date: 9 October 2001 (09.10.2001)
- (25) Filing Language: English
- (26) Publication Language: English
- (30) Priority Data:
60/239,194 10 October 2000 (10.10.2000) US
- (71) Applicant (for all designated States except US): **THE TRUSTEES OF COLUMBIA UNIVERSITY IN THE CITY OF NEW YORK** [US/US]; 116th Street and Broadway, New York, NY 10027 (US).
- (72) Inventor; and
- (75) Inventor/Applicant (for US only): **IM, James, S.** [US/US]; Apartment #74, 520 West 114th Street, New York, NY 10027 (US).
- (74) Agent: **TANG, Henry**; Baker Botts LLP, 30 Rockefeller Plaza, New York, NY 10112-0228 (US).
- (81) Designated States (national): AE, AG, AL, AM, AT, AU, AZ, BA, BB, BG, BR, BY, BZ, CA, CH, CN, CO, CR, CU, CZ, DE, DK, DM, DZ, EC, EE, ES, FI, GB, GD, GE, GH, GM, HR, HU, ID, IL, IN, IS, JP, KE, KG, KP, KR, KZ, LC, LK, LR, LS, LT, LU, LV, MA, MD, MG, MK, MN, MW, MX, MZ, NO, NZ, PH, PL, PT, RO, RU, SD, SE, SG, SI, SK, SL, TJ, TM, TR, TT, TZ, UA, UG, US, UZ, VN, YU, ZA, ZW.
- (84) Designated States (regional): ARIPO patent (GH, GM, KE, LS, MW, MZ, SL, SZ, TZ, UG, ZW), Eurasian patent (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European patent (AT, BE, CH, CY, DE, DK, ES, FI, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE, TR), OAPI patent (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, ML, MR, NE, SN, TD, TG).
- Published:
— with international search report
- (88) Date of publication of the international search report:
19 September 2002

[Continued on next page]

(54) Title: METHOD AND APPARATUS FOR PROCESSING THIN METAL LAYERS



(57) Abstract: A method and apparatus for processing a thin metal layer on a substrate to control the grain size, grain shape, and grain boundary location and orientation in the metal layer by irradiating the metal layer with a first excimer laser pulse having an intensity pattern defined by a mask to have shadow regions and beamlets. Each region of the metal layer overlapped by a beamlet is melted throughout its entire thickness, and each region of the metal layer overlapped by a shadow region remains at least partially unmelted. Each at least partially unmelted region adjoins adjacent melted regions. After irradiation by the first excimer laser pulse, the melted regions of the metal layer are permitted to resolidify. During resolidification, the at least partially unmelted regions seed growth of grains in adjoining melted regions to produce larger grains. After completion of resolidification of the melted regions following irradiation by the first excimer laser pulse, the metal layer is irradiated by a second excimer laser pulse having a shifted intensity pattern so that the shadow regions overlap regions of the metal layer having fewer and larger grains. Each region of the metal layer overlapped by one of the shifted beamlets is melted throughout its entire thickness, while each region of the metal layer overlapped by one of the shifted shadow regions remains at least partially unmelted. During resolidification of the melted regions after irradiation by the second radiation beam pulse, the larger grains in the at least partially unmelted regions seed growth of even larger grains in adjoining melted regions. The irradiation, resolidification and re-irradiation of the metal layer may be repeated, as needed, until a desired grain structure is obtained in the metal layer.

WO 02/031869 A3



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

International Application No
PCT/US 01/31391

A. CLASSIFICATION OF SUBJECT MATTER
IPC 7 H01L21/768

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 H01L B23K

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, INSPEC, PAJ

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	HAU-RIEGE C S ET AL: "The effects of microstructural transitions at width transitions on interconnect reliability" JOURNAL OF APPLIED PHYSICS, 15 JUNE 2000, AIP, USA, vol. 87, no. 12, pages 8467-8472, XP002200743 ISSN: 0021-8979 the whole document ----- -/--	1

Further documents are listed in the continuation of box C.

Patent family members are listed in annex.

° Special categories of cited documents :

- *A* document defining the general state of the art which is not considered to be of particular relevance
- *E* earlier document but published on or after the international filing date
- *L* document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)
- *O* document referring to an oral disclosure, use, exhibition or other means
- *P* document published prior to the international filing date but later than the priority date claimed

- *T* later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
- *X* document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
- *Y* document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.
- *G* document member of the same patent family

Date of the actual completion of the international search

31 May 2002

Date of mailing of the international search report

14/06/2002

Name and mailing address of the ISA

European Patent Office, P.B. 5818 Patentlaan 2
NL - 2280 HV Rijswijk
Tel. (+31-70) 340-2040, Tx. 31 651 epo nl,
Fax: (+31-70) 340-3016

Authorized officer

Königstein, C

INTERNATIONAL SEARCH REPORT

International Application No

PCT/US 01/31391

C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT		
Category	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	<p>SPOSILI R S ET AL: "SEQUENTIAL LATERAL SOLIDIFICATION OF THIN SILICON FILMS ON SiO₂"</p> <p>APPLIED PHYSICS LETTERS, AMERICAN INSTITUTE OF PHYSICS. NEW YORK, US, vol. 69, no. 19, 4 November 1996 (1996-11-04), pages 2864-2866, XP000955150 ISSN: 0003-6951 figure 1</p>	68-71
X	<p>MCWILLIAMS B M ET AL: "WAFER-SCALE LASER PANTOGRAPHY: FABRICATION OF N-METAL-OXIDE-SEMICONDUCTOR TRANSISTORS AND SMALL-SCALE INTEGRATED CIRCUITS BY DIRECT-WRITE LASER-INDUCED PYROLYTIC REACTIONS"</p> <p>APPLIED PHYSICS LETTERS, AMERICAN INSTITUTE OF PHYSICS. NEW YORK, US, vol. 43, no. 10, November 1983 (1983-11), pages 946-948, XP000816966 ISSN: 0003-6951 figure 1</p>	68
X	<p>MARIUCCI L ET AL: "Grain boundary location control by patterned metal film in excimer laser crystallized polysilicon"</p> <p>PROCEEDINGS OF THE FIFTH INTERNATIONAL CONFERENCE ON POLYCRYSTALLINE SEMICONDUCTORS (POLYSE '98), SCHWABISCH GMUND, GERMANY, 13-18 SEPT. 1998, vol. 67-68, pages 175-180, XP008004041 Diffusion and Defect Data Part B (Solid State Phenomena), 1999, Balaban Publishers; Scitec Publications, Switzerland ISSN: 1012-0394 the whole document</p>	1
A	<p>BROADBENT E K ET AL: "Excimer laser processing of Al-1%Cu/TiW interconnect layers"</p> <p>1989 PROCEEDINGS. SIXTH INTERNATIONAL IEEE VLSI MULTILEVEL INTERCONNECTION CONFERENCE (CAT. NO.89TH0259-2), SANTA CLARA, CA, USA, 12-13 JUNE 1989, pages 336-345, XP010092413 1989, New York, NY, USA, IEEE, USA the whole document</p>	1,20,31, 32,39, 49,67
A	<p>US 6 014 944 A (RUSSELL STEPHEN D ET AL) 18 January 2000 (2000-01-18) the whole document</p>	

-/--

INTERNATIONAL SEARCH REPORT

International Application No
PCT/US 01/31391

C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT		
Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	US 5 591 668 A (MAEGAWA SHIGEKI ET AL) 7 January 1997 (1997-01-07) figures 1A,1B -----	

INTERNATIONAL SEARCH REPORT
Information on patent family members

International Application No
PCT/US 01/31391

Patent document cited in search report		Publication date		Patent family member(s)	Publication date
US 6014944	A	18-01-2000	US	6176922 B1	23-01-2001
US 5591668	A	07-01-1997	JP	7249591 A	26-09-1995
			KR	153834 B1	01-12-1998