US006235563B1

(12) **United States Patent**
Oka et al.

(10) **Patent No.: US 6,235,563 B1**
(45) **Date of Patent: May 22, 2001**

(54) **SEMICONDUCTOR DEVICE AND METHOD OF MANUFACTURING THE SAME**

(75) Inventors: **Hideaki Oka**; **Satoshi Takenaka**; **Masafumi Kunii**, all of Suwa (JP)

(73) Assignee: **Seiko Epson Corporation**, Tokyo (JP)

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

(21) Appl. No.: **07/790,107**

(22) Filed: **Nov. 7, 1991**

Related U.S. Application Data

(63) Continuation of application No. 07/479,396, filed on Feb. 13, 1990, now abandoned.

(30) **Foreign Application Priority Data**

Feb. 14, 1989	(JP)	1-34140
Mar. 27, 1989	(JP)	1-74229
Mar. 27, 1989	(JP)	1-74230
Jun. 5, 1989	(JP)	1-142470
Oct. 4, 1989	(JP)	1-259393
Nov. 21, 1989	(JP)	1-302862

(51) **Int. Cl.**[7] **H01L 21/32**

(52) **U.S. Cl.** **438/166**; 438/485; 438/486

(58) **Field of Search** .... 437/173, 174, 437/967, 973, 83, 103, 109, 980, 983, 968, 913, 62, 485, 486, 166; 148/DIG. 1, DIG. 3, DIG. 90, DIG. 154, DIG. 122

(56) **References Cited**

U.S. PATENT DOCUMENTS

3,883,372	5/1975	Lin	148/187
4,129,463	12/1978	Cleland et al.	148/33

(List continued on next page.)

FOREIGN PATENT DOCUMENTS

3241959 5/1983 (DE) .
0261666 3/1988 (EP) .

(List continued on next page.)

OTHER PUBLICATIONS

N. Sax and R. Lewis, Sr. *Hawley's Condensed Chemical Dictionary* 11th Ed. (1987) Van Nostrand Reinhold Co. pp. 562, 563, 164.*

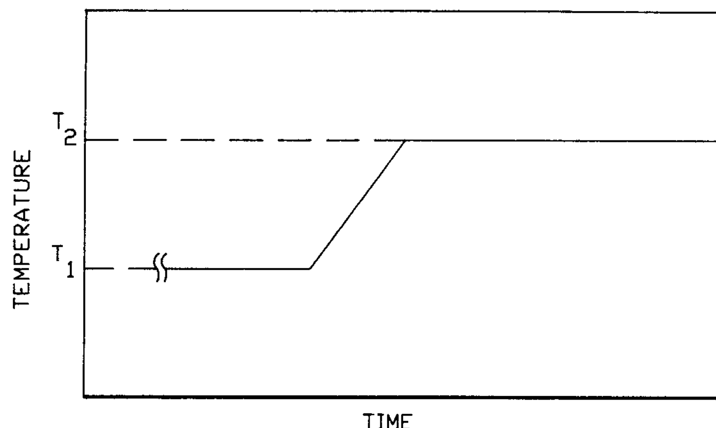
P. Kwizera et al., "Solid Phase Epitaxial Recrystallization of Thin Polysilicon Films Amorphized by Silicon Ion Implantation", *Applied Physics Letters*, vol. 41(4), pp. 379–381, Aug. 15, 1982 (Including vol./No. content page).

Primary Examiner—Charles Bowers
Assistant Examiner—Matthew Whipple

(57) **ABSTRACT**

An improved polycrystalline or polysilicon film having large grain size, such as 1 μm to 2 μm in diameter or greater, is obtained over the methods of the prior art by initially forming a silicon film, which may be comprised of amorphous silicon or micro-crystalline silicon or contains microcrystal regions in the amorphous phase, at a low temperature via a chemical vapor deposition (CVD) method, such as by plasma chemical vapor deposition (PCVD) with silane gas diluted with, for example, hydrogen, argon or helium at a temperature, for example, in the range of room temperature to 600° C. This is followed by solid phase recrystallization of the film to form a polycrystalline film which is conducted at a relatively low temperature in the range of about 550° C. to 650° C. in an inert atmosphere, e.g., N or Ar, for a period of about several hours to 40 or more hours wherein the temperature is gradually increased, e.g., at a temperature rise rate below 20° C./min, preferably about 5° C./min, to a prescribed recrystallization temperature within the range about 550° C. to 650° C. Further, between the step of film formation and the step of solid phase recrystallization, the film may be thermally treated at a relatively low temperature, e.g., over 300° C. and preferably between approximately 400° C. to 500° C. for a period of several minutes, such as 30 minutes, to remove hydrogen from the film prior to solid phase recrystallization.

41 Claims, 11 Drawing Sheets



DOCKET ALARM Find authenticated court documents without watermarks at docketalarm.com.

U.S. PATENT DOCUMENTS

4,249,957		2/1981	Koliwad et al.	136/258
4,314,595	*	2/1982	Yamamoto et al.	437/247
4,377,605	*	3/1983	Yamamoto	437/239
4,432,809	*	2/1984	Chye et al.	437/247
4,448,632		5/1984	Akasaka	156/603
4,471,523		9/1984	Hu	29/571
4,552,595		11/1985	Hoga	148/1.5
4,581,814	*	4/1986	Celler et al.	437/62
4,597,804	*	7/1986	Imaoka	437/247
4,751,196	*	6/1988	Pennell et al.	437/84
4,772,486	*	9/1988	Ishihara et al.	437/173
4,814,292	*	3/1989	Sasaki et al.	148/DIG. 1
4,905,072		2/1990	Komatsu et al.	357/59

FOREIGN PATENT DOCUMENTS

0296747		12/1988	(EP) .	
158431	*	12/1981	(JP)	437/247
79718	*	5/1983	(JP)	437/247
10573	*	1/1988	(JP) .	
42112		2/1988	(JP) .	
2-81421		3/1990	(JP) .	

* cited by examiner

DOCKET ALARM Find authenticated court documents without watermarks at docketalarm.com.

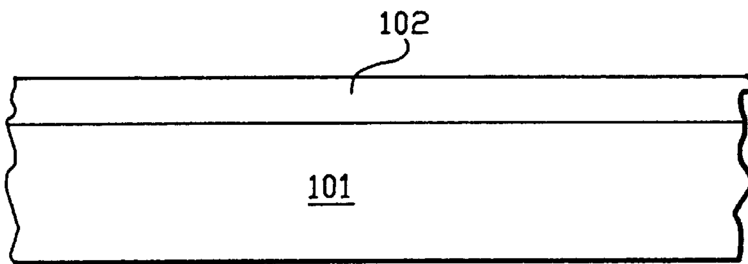


FIG.-1A

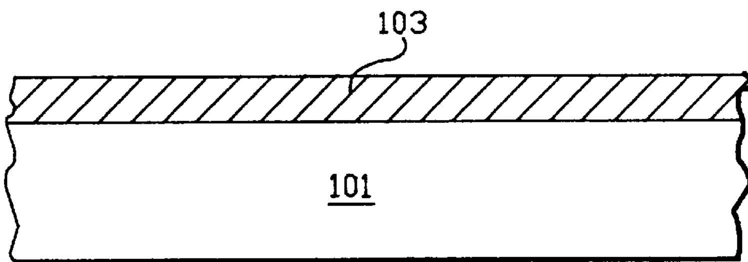


FIG.-1B

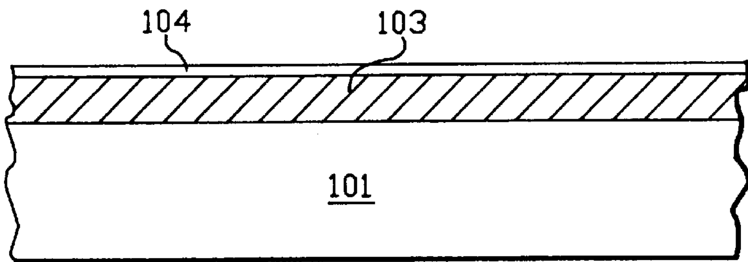


FIG.-1C

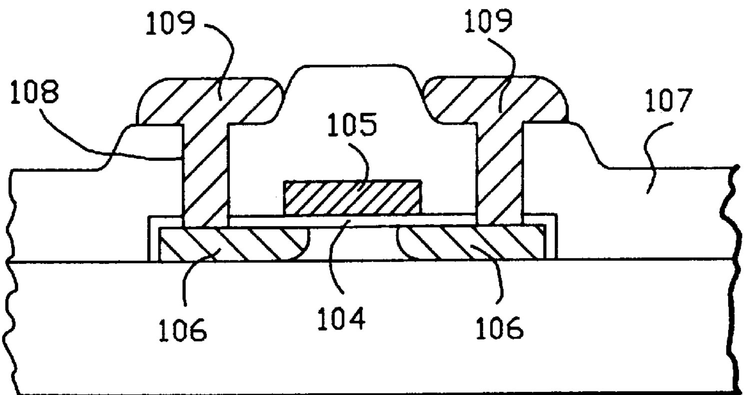


FIG.-1D

DOCKET ALARM Find authenticated court documents without watermarks at docketalarm.com.

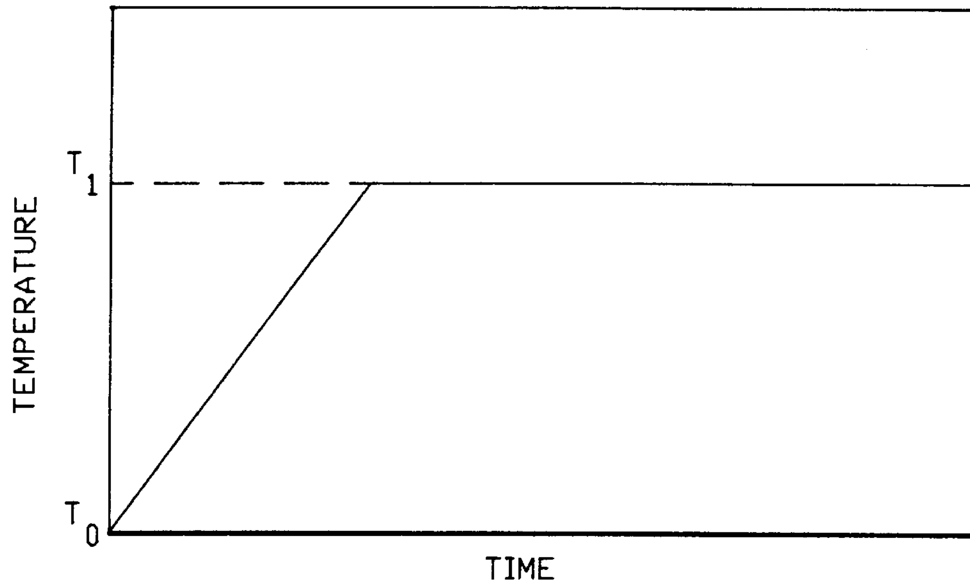


FIG.-2A

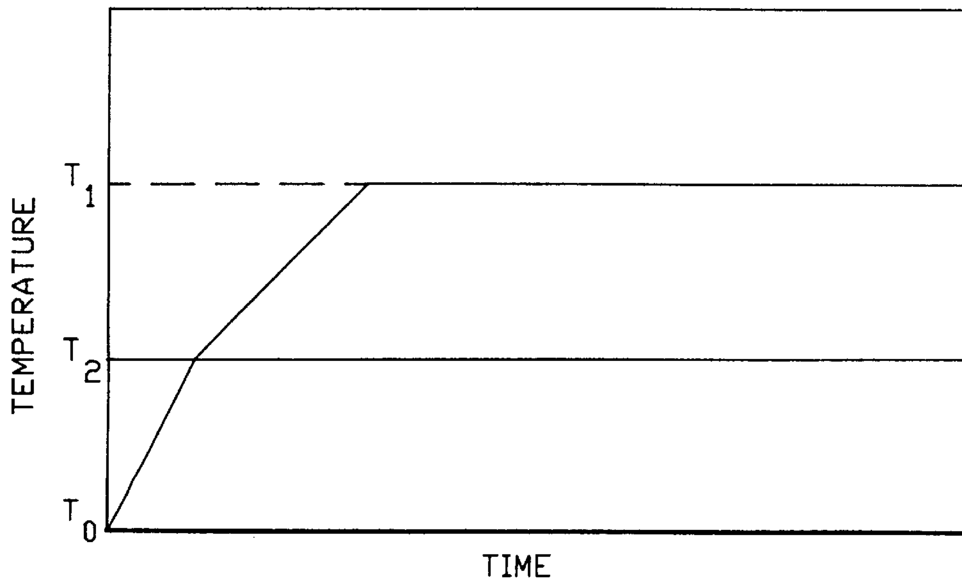


FIG.-2B

DOCKET ALARM
Find authenticated court documents without watermarks at docketalarm.com.

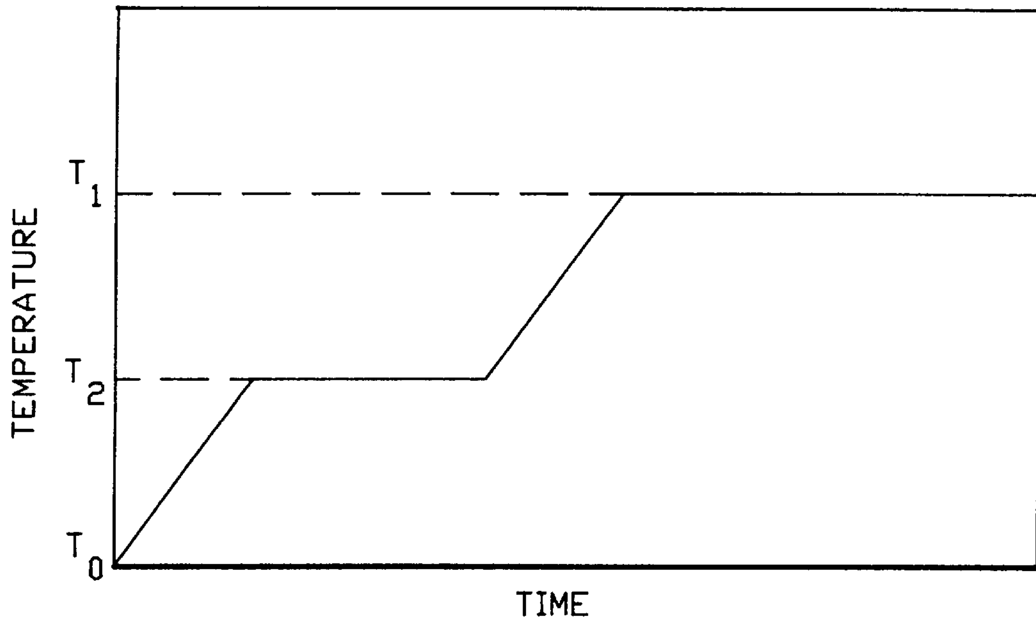


FIG.-2C

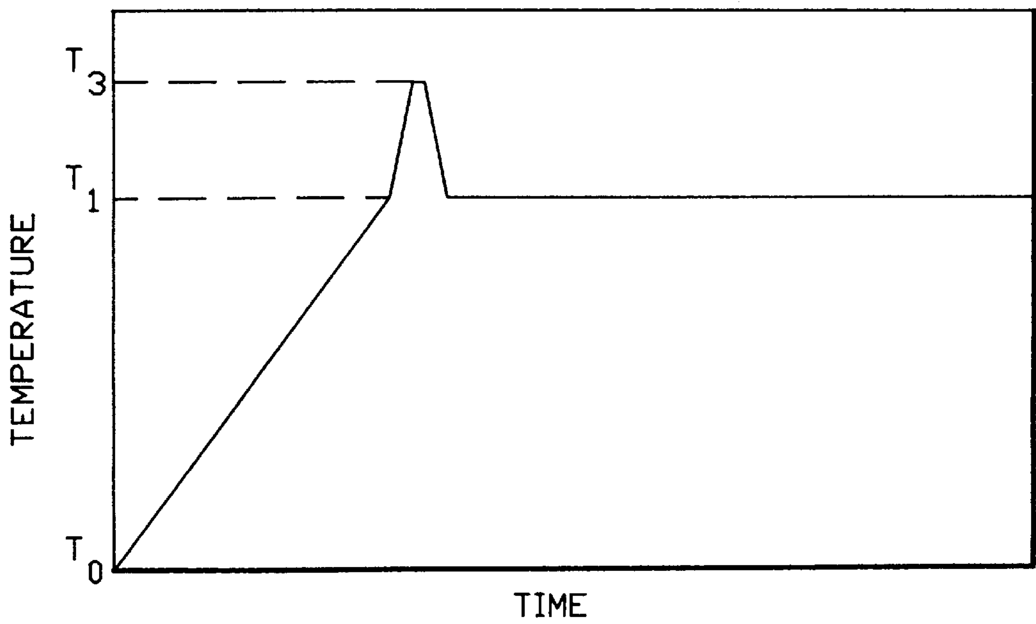


FIG.-2D

DOCKET ALARM Find authenticated court documents without watermarks at docketalarm.com.

DOCKET ALARM

Explore Litigation Insights

Docket Alarm provides insights to develop a more informed litigation strategy and the peace of mind of knowing you're on top of things.

Real-Time Litigation Alerts

Keep your litigation team up-to-date with **real-time alerts** and advanced team management tools built for the enterprise, all while greatly reducing PACER spend.

Our comprehensive service means we can handle Federal, State, and Administrative courts across the country.

Advanced Docket Research

With over 230 million records, Docket Alarm's cloud-native docket research platform finds what other services can't. Coverage includes Federal, State, plus PTAB, TTAB, ITC and NLRB decisions, all in one place.

Identify arguments that have been successful in the past with full text, pinpoint searching. Link to case law cited within any court document via Fastcase.

Analytics At Your Fingertips

Learn what happened the last time a particular judge, opposing counsel or company faced cases similar to yours.

Advanced out-of-the-box PTAB and TTAB analytics are always at your fingertips.

API

Docket Alarm offers a powerful API (application programming interface) to developers that want to integrate case filings into their apps.

LAW FIRMS

Build custom dashboards for your attorneys and clients with live data direct from the court.

Automate many repetitive legal tasks like conflict checks, document management, and marketing.

FINANCIAL INSTITUTIONS

Litigation and bankruptcy checks for companies and debtors.

E-DISCOVERY AND LEGAL VENDORS

Sync your system to PACER to automate legal marketing.

WHAT WILL YOU BUILD? | sales@docketalarm.com | 1-866-77-FASTCASE

fastcase® Smarter legal research.