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Patent
Attorney's Docket No. 008442-028
(formerly 51960.P017d)

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In re Patent Application of	
Glenn J. Leedy	
Application No.: 08/315,905	Group Art Unit: 1104
Filed: September 30, 1994	Examiner: Dang, T.
For: METHOD OF MAKING DIELECTRICALLY ISOLATED INTEGRATED CIRCUITS (as amended)	

DECLARATION OF DR. ALAIN HARRUS

Assistant Commissioner for Patents
Washington, D.C. 20231

Sir:

I, DR. ALAIN HARRUS, declare that:

1. I hold a doctorate degree in Physics from Temple University (Philadelphia), having completed my doctorate program in 1984.

2. During a period of approximately five years from 1985 to 1989, I was a Member of Technical Staff at the Silicon Processing Laboratory of Bell Laboratories in Allentown, Pennsylvania. My responsibilities were focused in the area of semiconductor manufacturing process development, particularly plasma processes and dielectric processes.

3. In 1989, I joined Novellus Systems as Senior Technologist and was promoted to Director of Technology for Dielectrics in 1990, having responsibility for the product line of dielectric deposition systems, including interacting with customers, developing new processes, supporting existing processes, troubleshooting problems in the field, device integration, etc.

4. I left Novellus in 1993 to join LAM research, another semiconductor equipment manufacturer, where I worked in the CVD Division. I returned to Novellus in 1994 as Director of Strategic Marketing.

5. I am currently Chief Technical Officer of Novellus, a position I have held since 1996.

6. In 1988 or so, Novellus introduced a dual-RF PECVD deposition system. This system provided for the first time a mechanism to control the stress of deposited films. One RF source is high frequency, and the other RF source is low frequency. Stress is controlled by varying the energy ratio of the high and low frequency RF sources. The main role of the high-frequency RF is to generate the reactive species and provide sufficient electron and ion densities. The low frequency is added to control the ion bombardment to which the substrates are subjected during deposition. Increasing the low-frequency power increases the plasma potential and the amount of ions following the low-frequency RF field (<1 MHz). The resulting low-energy ion implantation occurring during deposition causes a change in the intrinsic film stress from tensile to compressive, increases film density, and improves the chemical reactions.

7. Stress level measurements of dielectric films are often spoken of and depicted in "units" of 1 x 10^9 dynes/cm^2, with "+" being used to denote tensile stress and "-" being used to denote compressive stress. Both integer and decimal values may be used, for example:

COMPRESSIVE	-5	-5 x 10^9 dynes/cm^2
	-4	-4 x 10^9 dynes/cm^2
	-3	-3 x 10^9 dynes/cm^2
	-2	-2 x 10^9 dynes/cm^2
	-1	-1 x 10^9 dynes/cm^2
	-0.1	-0.1 x 10^9 dynes/cm^2
ZERO	0	0 x 10^9 dynes/cm^2
TENSILE	0.1	0.1 x 10^9 dynes/cm^2
	1	1 x 10^9 dynes/cm^2
	2	2 x 10^9 dynes/cm^2
	3	3 x 10^9 dynes/cm^2

8. At Novellus, I would be approached by customers having various different film requirements. Most of these requirements were quite conventional. Most customers requested films having a stress of about -1. Customers were not interested in tensile films because of the propensity of such films to crack. Dielectric films are often used as passivation layers, cracking of which can result in device contamination and failure in the field.

9. In 1990, I was approached by Glenn Leedy about the feasibility of producing a thick dielectric film having very low tensile stress. This was a very unconventional request, one that, to my knowledge, no customer had made before.

10. At the time Mr. Leedy made his request, Novellus had completed a substantial body of work regarding stress control of thin films. This work suggested in theory that, by controlling deposition parameters (principally the ratio of high frequency RF energy to low frequency RF energy), film stress could be controlled anywhere along a line passing through zero and extending from about -5 to +3. Attached is a page from Novellus's Process Guide for Silicon Nitride. The figure at the bottom of the page shows the theoretical curve for stress versus percentage of low-frequency power, together with data points corresponding to films actually produced. In practice, however, the lowest tensile stress film produced at Novellus prior to receiving Mr. Leedy's request was, according to my recollection, about +1.

11. Based on my experience, I responded to Mr. Leedy that I thought that Novellus could produce a film that would meet his requirements. Under my direction, an engineer then undertook a series of experiments, conducted over a period of several days, demonstrating that indeed a thick low stress tensile dielectric film could be produced, having a stress level of about 0.1 or less, an order of magnitude or more lower than tensile films that had previously been produced at Novellus.

12. I have reviewed U.S. Patent 4,702,936 to Maeda et al. From the limited information presented in the patent, I believe that it is impossible to say with any degree of certainty what the stress level of films produced in accordance with the teachings of

the patent would be. For example, no mention is made in Maeda et al. of the reactor pressure, an important process variable. The important process variables in the Novellus process used to produce low stress tensile dielectric films for Mr. Leedy included temperature, pressure, high frequency RF power, low frequency RF power, and flow rates of various chemical constituents (Specification, page 21).

13. Both chemistry and activation play an important role in determining film characteristics. Similarities in chemistry (or even identical chemistry) simply cannot be used to predict film similarity apart from considerations of activation. The same chemistry coupled with different activation can produce entirely different results. In the case of Maeda et al., the UV activation process employed differs greatly from the dual RF activation process used at Novellus to produce films for Mr. Leedy. To draw an analogy, the same ingredients, flour and water may be used to make a pizza or may be used to make a cake.

14. Based on my experience, I do believe that films produced in accordance with the teachings of Maeda et al. would have tensile stress. However, Maeda et al. provides no mechanism for controlling the stress level, i.e., no mechanism akin to varying the ratio of high frequency to low frequency energy as in the case of the Novellus system. The ability to produce a low tensile stress layer relies on the ability to control stress with an independent mechanism or "knob." No such knob is present in Maeda et al.

15. Silicon nitride intrinsically goes down at relatively high levels of tensile stress (e.g., +1) in accordance with both thermal deposition and high frequency PECVD. Furthermore, other work using similar chemistry and UV activation as Maeda et al. has resulted in films having stresses of about +7. Note, for example, Nagayoshi, et al., "Residual Stress of a $Si_{1-x}N_x$:H Films Prepared by Afterglow Plasma Chemical Vapor Deposition Technique", *Jpn. J. Appl. Phys.*, Vol. 31, pp. L867-L869 (1992), a copy of which is attached hereto.

16. The undersigned declares further, that all statements made herein of his own knowledge are true, and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false

statements and the like so made are punishable by fine or imprisonment, or both, under Section 1001 of Title 18 of the United States Code, and that such willful false statements may jeopardize the validity of the application or any patent issuing thereon.

Dated: 11/07/97 Alain Harrus
Alain Harrus