PLASMA TREATMENT ENHANCED STRESS BEHAVIOR, CHEMICAL AND THERMAL STABILITY OF ADVANCED SIC:H FILM

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A new amorphous SiC:H film is deposited by Plasma Enhanced Chemical Vapour Deposition (PECVD) using an advanced liquid precursor [1]. Due to its physical and chemical properties (table 1) this type of layer can be employed for various applications in damascene interconnect scheme such as dielectric hard-mask and copper barrier applications in a 65nm or sub 65 nm node technology. In this paper, mechanical, chemical and thermal improvements following developments on this SiC:H film are reported.

Plasma treatments are aimed at improving film stability and adhesion with other dielectric materials. Treatments can be reactive and non-reactive one. They are carried out under various conditions (temperature, pressure, power, gas flow). Two optimized plasma treatments are reported here (non-reactive: treat A / reactive: treat B). Influence of these treatment on the SiC:H film are investigated using several characterizations. Rutherford Backscattering Spectrometry (RBS), Nuclear Reaction Analysis (NRA), Elastic Recoil Detection Analysis (ERDA) and X-Ray Photoelectrons Spectroscopy (XPS) allow to determinate atomic composition of as-deposited and treated films. Thermal behavior is studied using thermal desorption spectroscopy. Stress evolution up to 450°C is also computed and analyzed. Plasma treatments effects on adhesion properties between SiC:H film and dielectric materials are studied using four points bending adhesion measurements. Electrical characteristics (dielectric constant k, leakage current, breakdown voltage) are carried out on a mercury probe system and H_2O wetting angle is measured before and after each treatments.

As-deposited material stress evolution shows low hysteresis of 60 MPa (figure 1). This is certainly due to structural re-organization between 325°C and 425°C (negative slope becomes positive). After both plasma treatments, thermal behavior of the film is improved, in term of a stress hysteresis decrease (40 MPa) and a minimized film re-organization over 325°C. XPS, RBS and NRA analysis reveal that atomic compositions of the film are remained after these two treatments. On the other hand, H_2O wetting angle results (table 2) show that hydrophobic characteristic of this film can be adjusted: while reactive plasma treatment B only slightly decreases material wetting angle (about 75° for as-deposited film, and 60° for treatment B), treatment A significantly modify the surface (30°). Electrical characteristics of treated film are stable after non-reactive treat A, they are improved with reactive treat B (decreasing leakage current and increase breakdown voltage). Oxygen plasma resistance of our film is greatly enhanced by these treatments. These surface treatment effects on SiC:H film are controlled using four points bending experiments results.

This work demonstrates the capability of plasma treatments to improve layer properties. In term of stress behaviour and thermal stability, this new SiC:H film is a serious candidate for 65nm technology and below.

This work has been carried out in the frame of CCMC consortium between CEA-DTR-LETI, STMicroelectronics and FRANCE TELECOM-R&D in collaboration with Applied Materials Europe.

[1] B. Rémiat, F. Gaillard, J. Durand, F. Fusalba, V. Jousseaume, C. Le Cornec, P. Maury, *Copper-barrier and hard-mask elaboration by plasma-enhanced chemical vapor deposition using organosilane precursor,* 202nd Meeting of ECS in Salt Lake City, 2002.

Table 1 : *new SiC:H film physical and mechanical properties.*

Material	k	Stress (Mpa)	R.I.	Leakage current @1MV/cm (A/cm2)
SiC	3,2	-100	1,67	4,00E-10

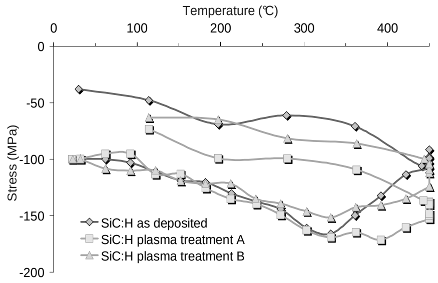

Figure 1 : *SiC:H thermal stress behavior.*

Table 2 : *new SiC:H film H2O wetting angle results***.**

Treatment	H_2O wetting angle
as-deposited	**75°**
Treatment A	**30°**
Treatment B	**60°**