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Comparison between UV and EB cure method for porous PAr / porous MSX hybrid structure

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Abstract

New developed post cure techniques (electron beam (EB) cure and ultraviolet (UV) cure) realize high mechanical strength, high adhesion strength, and low thermal budget (low temperature and short time cure) without k value increasing for SOD (spin-on dielectric) materials. These improvements of film characteristics are keys to fabricate PAr(Poly-arylene)/MSX(Methyl-siloxane) hybrid DD structure. EB can be used as simultaneous cure for PAr/MSX, however UV cure is needed to use optimized wavelength for each films. The simultaneous EB Cure method for hybrid DD is very effective for cost reduction.

Introduction

Hybrid DD structure using PAr/MSX stack carries out high reliable Cu/low-k multilevel interconnection [1-2]. Although hybrid DD has advantages that are excellent etching shape and ashing free process, meanwhile it has disadvantages that are lots of interfaces and complex scheme. In this paper, new developed post cure is applied to porous PAr/porous MSX stack structure, and clarify the deference between EB and UV cures.

Experiments

As low-k materials, porous MSX (JSR Corporation) and porous PAr (Dow chemical) are used for via and trench layer material respectively. EB cure process condition is follows: wafer temperature was 350ºC and chamber pressure was 1 Torr constant in He. The accelerating voltage of electrons was controlled optimally according to the film thickness. Electron dosage was controlled by irradiation time basically. UV cure process: wafer temperature was 350ºC in N2 without vacuum pressure. UV dosage was also controlled by irradiation time.

Results and Discussions

(1) Characterization of porous MSX

Fig. 1 shows k value of 130-nm MSX as a function of EB and UV cure time. UV wavelength of lamp was optimized for MSX cure. With each method, k value is less than 2.4 below 5 min cure. In the case of thermal cure (350ºC, 20 min), k value was 2.54.

As shown in fig. 2, film shrinkage increases monotonously with EB and UV cure time increasing. Fig. 3 and 4 show k value and modulus as a function of film shrinkage. From fig. 3 and 4, it was obvious that k value and modulus do not depend on cure method by normalization using film shrinkage. By FT-IR spectra of EB and UV cured film, Si-CH_3 and Si-O cage shows similar reduction by post cure.

(2) Characterization of porous PAr

Fig. 5 and 6 show film k value and shrinkage of porous PAr film as a function of cur time. As shown in Fig. 7, k value does not depend on cure method. For PAr cure, UV lamp was optimized with the viewpoint of porogen burn out and matrix cross-linkage. With each cure methods, k value is around 2.4 by 10 min cure. Acceleration of porogen burnout can be possible because IR peak originated in porogen can disappear rather than thermal cure method, and matrix can be cross-linked rather than thermal cure method by Raman spectra analysis. From these results it was concluded that both EB cure and UV cure are very effective to cure porous SOD materials.

(3) Characterization of PAr/MSX stack structure

Simultaneous EB cure was applied to PAr/MSX hybrid stack structure (fig.8). As shown in table 1, each film shows desired shrinkage value, and it can be considered that a simultaneous cure is possible. An electron penetration depth can be controlled by accelerated voltage in response to film thickness.

On the other hand, table 2 shows that a simultaneous UV cure is very difficult to apply to PAr/MSX stack structure, because UV source has to be optimized to PAr film and MSX film respectively. However, 2step UV cure process can be used for the stack structure. 2step process is follows: MSX film was coated and then cured by MSX optimized source, next PAr film was coated and then cured by optimized source.

In the case of UV cure, a suitable UV lamp selection is very note to improve each film performance. EB Cure method does not strongly depend on film used as an ILD. From these results, it was concluded that EB cure can be used to cure the stack films simultaneously.

Conclusions

EB and UV post cure techniques was compared in terms of mechanical strength, thermal budget and simultaneous cure possibility. EB can be used as simultaneous cure for PAr/MSX, however UV cure is needed to use optimized wavelength for each films. The simultaneous EB Cure method for hybrid DD is very effective for cost reduction.

Acknowledgments

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References

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[2]. R. kanamura et al, 2003 Symp. of VLSI Tech., P.107

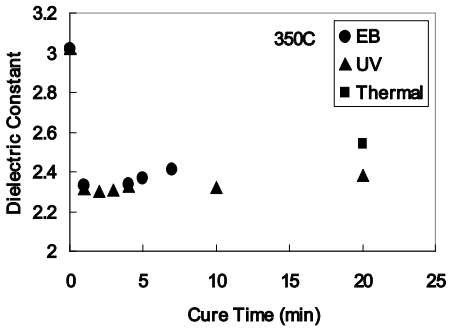

Figure 1: k value of 130-nm MSX
as a function of EB and UV cure time.

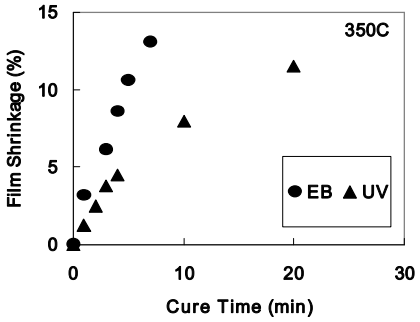

Figure 2 : Film shrinkage
as a function of EB and UV cure time.

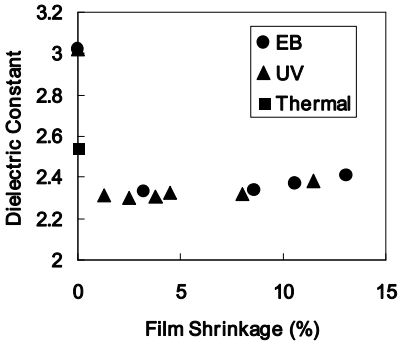

Figure 3 : Dielectric constant
as a function of film shrinkage.

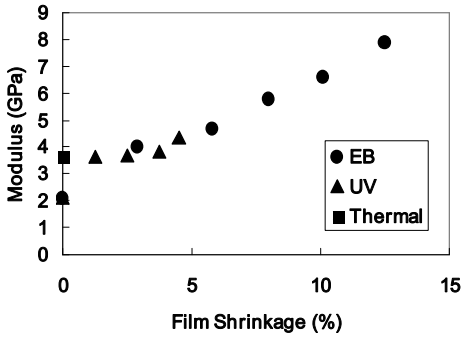

Figure 4 : Modulus as a function of film shrinkage.

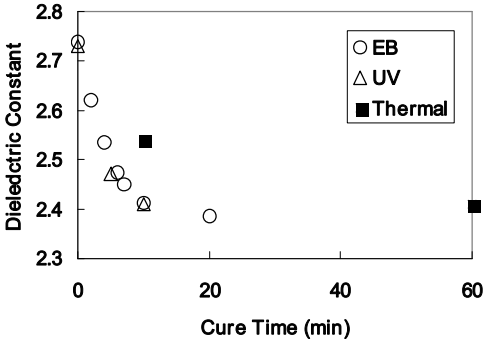

Figure 5 : k value of 100-nm PAr
as a function of EB and UV cure time.

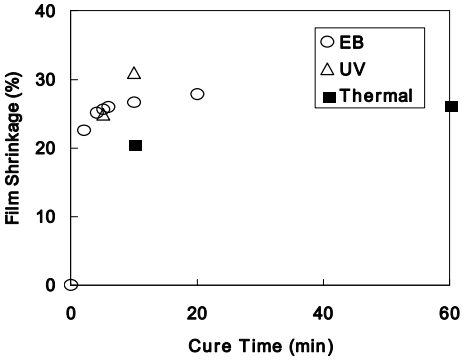

Figure 6 : Film shrinkage
as a function of EB and UV cure time.

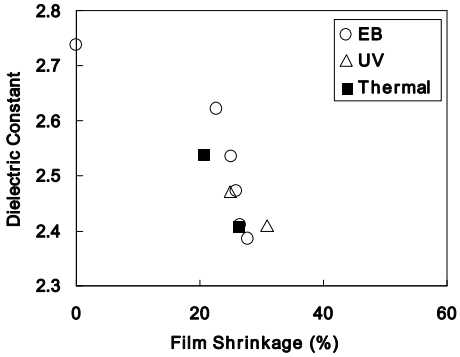

Figure 7 : Film shrinkage
as a function of EB and UV cure time.

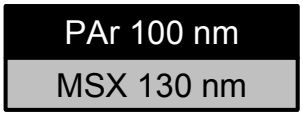

Figure 8 : PAr/MSX hybrid stack structure.

Table 1 : Shrinkage of PAr and MSX.

Structure	film	PAr Shrinkage (%)	MSX Shrinkage (%)
single layer	PAr	25.4	
	MSX		10.6
stacked layer	PAr / MSX	26.1	8.5

Table 2. : The dielectric constant cured by each UV source.

	PAr film property		MSX film property	
UV source optimized for film	MSX	PAr	MSX	PAr
film shrinkage (%)	37.7	26.6	8.0	0
k	2.68	2.41	2.32	2.45
	bad	Good	Good	no change