Cu BARRIER PROPERTY OF LOW-K SiOCH FILM WITH K=3.5 DEPOSITED BY PE-CVD USING HMDSO AND N2O GASES

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The low-k copper (Cu) barrier dielectric film is indispensable for fabrication of high-end devices. We have developed the Cu barrier film (1-3).

We studied the property of the film with k value 3.5 deposited by PE-CVD using HMDSO, N2O and He gases and clarified the Cu barrier ability of the film. The film was deposited on Cu film and annealed at 450 °C for 4 hours in nitrogen (N2). We compared the Cu barrier ability for the films with different k values. The leakage currents before and after thermal annealing are shown in Fig. 1. The films with k values of 3.5, 3.1 and 2.9 have low leakage currents before and after annealing. However, the film with k value of 2.7 initially shorted after annealing. The breakdown electric field decreases, and the leakage current increases with decreasing k value after annealing. The film with k value of 3.5 has the breakdown field relatively high value of 4.0 MV/cm after annealing. This fact suggests that the film with k value of 3.5 has the good barrier ability to Cu diffusion. We measured the leakage current at 5 points on the wafer to ensure the stability of the characteristics. The characteristic of the leakage current is very stable. We investigated the Cu diffusion profiles before and after annealing by SIMS. The Cu diffusion depth profiles do not change in the films with k value of 3.5 and 3.1, but the Cu concentration in the film with k value of 3.1 is large (10^{18} atoms/cm^3) at the boundary between Cu and the barrier film after annealing. The Cu concentrations in the films with k value 2.9 and 2.7 increase at the boundary after annealing. The stacked film composed by the film of 10 nm with k value 3.5 and the film of 90 nm film with k value 2.7 has also good Cu barrier property as shown in Fig. 2. It is found that Cu surface control is important to prevent Cu diffusion into low-k interlayer dielectric film. The barrier mechanism of the SiOCH film with 3.5 was studied from the viewpoint of the pore distribution, average pore size, density and chemical bonds. The barrier ability is caused by single type distribution with relatively small average pore size 0.72 nm as shown in Fig. 3 and the relatively large density (1.83 g/cm^3).

The film with k value of 3.5 is found to have good Cu barrier ability and will be useful for reducing the effective k value of the inter-layer dielectric film used in high-end logic devices under 100 nm.

REFERENCES

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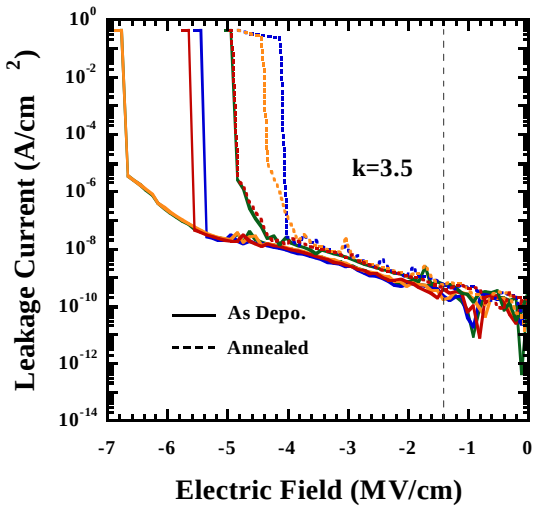

Fig. 1 Leakage current of Cu barrier SiOCH film before and after annealing. The film was deposited on Cu film.

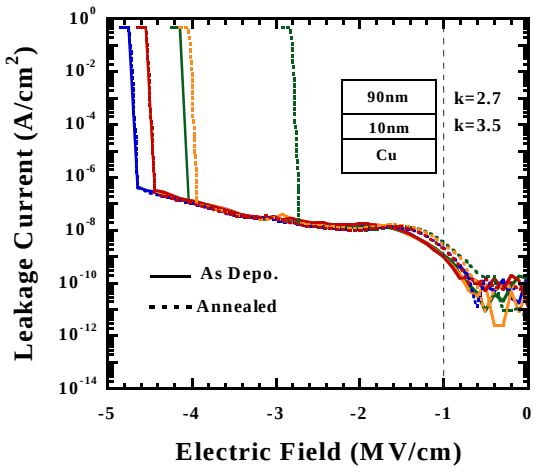

Fig. 2 Leakage current of stacked film with k value of 3.5 before and after annealing.
The film was deposited on Cu stacked film.

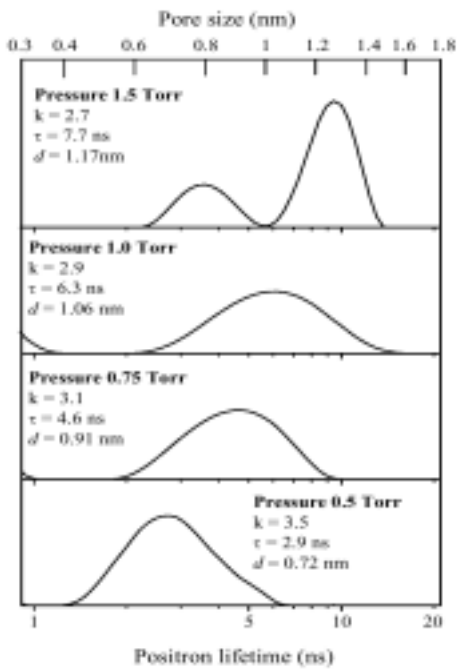

Fig. 3 Pore size of SiOCH film measured by PALS.