Process Performance of H_2 Remote Plasma Based Photoresist Ashing Processes and Their Influence on ULK Materials Modifications

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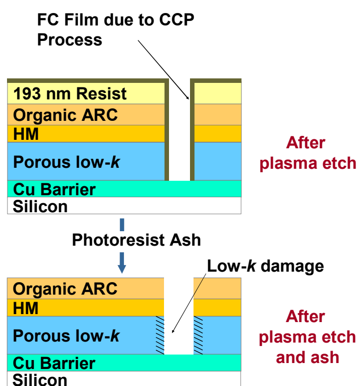
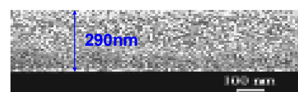
Introduction

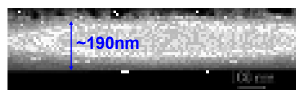


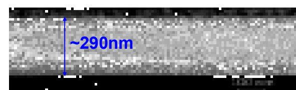
Application of porous low dielectric (low-*k*) materials with k_{eff} below 2.6 is necessary to achieve next generation (45nm node) VLSI devices. However, conventional O_2 remote ashing damages porous low-*k* materials to an unacceptable level.

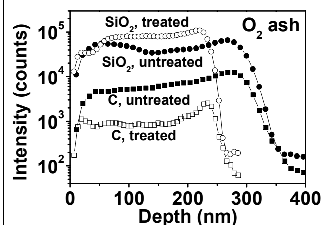


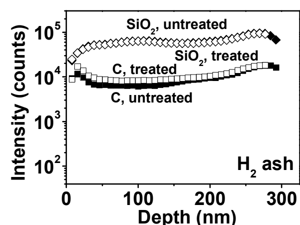
O_2 Ash

H_2 Ash







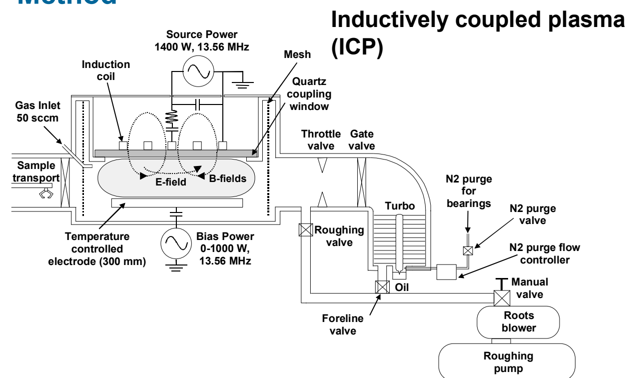


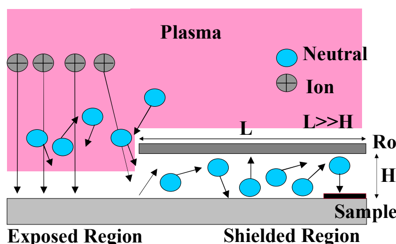
Nanopores enhance carbon depletion and densification under O_2 remote plasma.

Compared with O_2, H_2 remote plasma does not damage low-*k* materials and is potential candidate for ashing process integrated with low-*k* materials.

Method

Inductively coupled plasma (ICP)

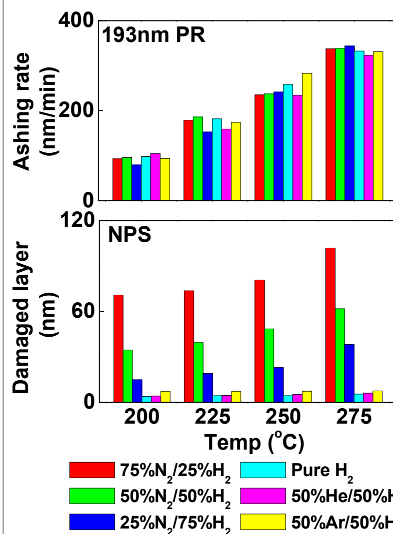




A small gap structure was employed to generated remote plasmas.

Source power: 1000W
Pressure: 100mTorr
Flow rate: 50sccm
Processing time: 1min

Results

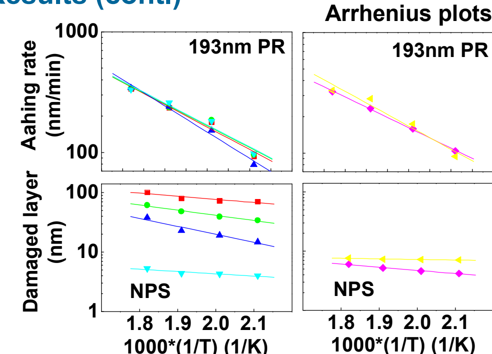


Both ashing rate and low-*k* damaged level increased strongly with substrate temperature.

N_2 addition to H_2 remote plasmas does not increase 193 PR ashing rate but low-*k* materials damaged level.

Results (cont.)

Arrhenius plots



Activation energy (eV)

	$75\%N_2/25\%H_2$	$50\%N_2/50\%H_2$	$25\%N_2/75\%H_2$	Pure H_2	$50\%He/50\%H_2$	$50\%Ar/50\%H_2$
193PR	0.37	0.36	0.43	0.36	0.34	0.38
NPS	0.10	0.17	0.27	0.08	0.11	0.02

- High activation energies of $25\%N_2/75\%H_2$ chemistry correspond to the generation of ammonia.
- Activation energy of ashing (~0.4 eV) was higher than that of low-*k* damage(~0.1eV).

Conclusions

- For our remote plasma, elevated substrate temperature (200 to 275 °C) conditions, N_2 addition to H_2 is ineffective in reducing porous low-*k* damage relative to (PR) ashing rate.
- The higher activation energy of PR ashing (~0.4 eV) than that of porous low-*k* damage introduction (~0.1 eV) for remote plasma processing favors a higher substrate temperature for ashing process optimization.

Acknowledgements

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