LOW TEMPERATURE SOLUTION FOR SILICON NITRIDE LPCVD USING Cl-FREE INORGANIC TRISILYLAMINE

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With the shrinkage of the critical dimension in semiconductor devices towards 100 nm in a near future, the need to maintain sharp dopant concentration profiles throughout the complete chip manufacturing creates a strong constraint on the allowed thermal budget for the post-implantation process steps[1]. When performed with a dichlorosilane-ammonia (DCS-NH_3) chemistry, the low pressure chemical vapor deposition (LPCVD) of Si_3N_4 is one of the most budget-hungry process since a temperature in the 720-800^{o}C range is required to achieve a sufficient deposition rate.

Recently, two new low temperature silicon nitride precursors, with different pros and cons, have been proposed to tackle this issue, namely hexachlorodisilane[2] (Si_2Cl_6, HCD) and BTBAS™ ($SiH_2(NH$*t*$Bu)_2$)[3]. On one hand, HCD yields high quality Si_3N_4 films at low temperature, but it results, as for DCS, in the generation of NH_4Cl, which deposits in the exhaust line. On the other hand, if BTBAS has the advantage of being “exhaust friendly” since it does not contain chlorine, it tends to incorporate higher levels of carbon and hydrogen, the latter being known to be detrimental to block the diffusion of boron.

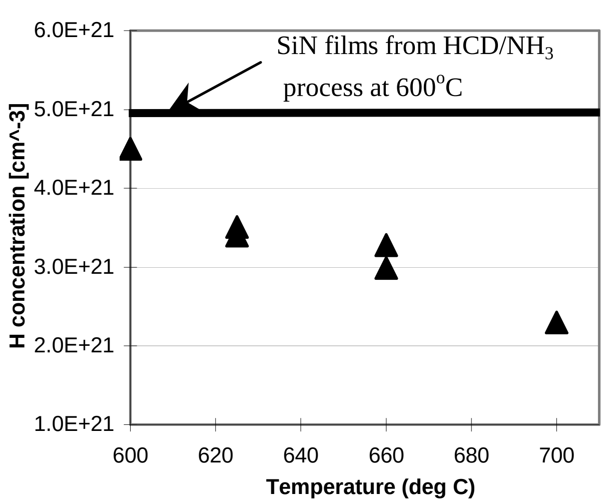
A new precursor, trisilylamine (TSA, $(SiH_3)_3N$), has been considered in order to optimize the film properties and deposition kinetics, taking into account several advantages of this chemical:

- Chlorine and carbon-free
- Direct Si-N bonds in the molecule
- Stable, and therefore convenient to use
- Very volatile (vapor pressure: 315 Torr at 25^{o}C)

Low-pressure chemical vapor deposition (LPCVD) of silicon nitride was achieved at low temperature (between 560 and 700^{o}C) using TSA. Silicon nitride films deposited with TSA and ammonia below 600^{o}C gave excellent conformal step coverage (Fig. 1) and activation energy of about 60 kcal/mol (Fig. 2) without any accumulation of solid byproducts in the exhaust line. As a result of the chemical composition of TSA, these films were also free of chlorine and carbon contamination. The hydrogen concentration in the films (Fig. 3), a critical feature related to boron diffusion from the substrate, is as low as the standard silicon nitride processes.

Fig. 1: Step coverage as a function of deposition temperature (Aspect ratio= 7)

Fig. 2: Deposition rate as a function of temperature



[1] [illegible]
[2] [illegible]
[3] Laxman et al., VMIC proc. 1998, p.568

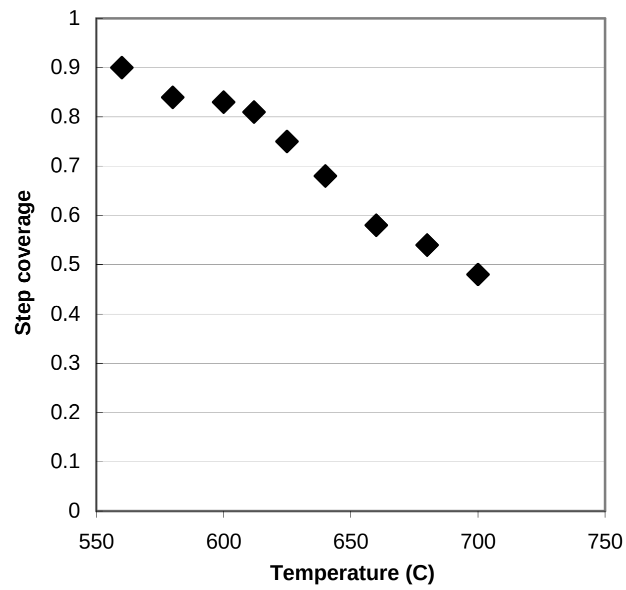


Fig. 3: H concentration as a function of deposition temperature