Annealsys, TSMC and National Central University amorphous boron nitride

Ultralow-k Amorphous Boron Nitride Based on Hexagonal Ring Stacking Framework for 300 mm Silicon Technology Platform.

Montpellier, France, August 1st, 2022

Publication of work performed in cooperation between Taiwan Semiconductor Manufacturing Company, National Central University and Annealsys.

Abstract

The implementation of ultralow dielectric constant (*k* value ≈ 2) materials to reduce signal propagation delay in advanced electronic devices represents a critical challenge in next generations of microelectronics technologies. The introduction of well-stacked and low polarity molecules that do not compromise film density may lead to improvements and desirable material engineering, as conventional porous SiOx derivatives exhibit detrimental degradation of thermo-mechanical properties when their *k* values are further scaled down. This work presents a systematic engineering approach for controlling ultralow-*k* amorphous boron nitride (aBN) deposition on 300 mm Si platforms. The results indicate that aBN grown from borazine precursor exhibits ultralow dielectric constant ≈2, high density, excellent mechanical strength, and extended thermodynamic stability. Unintentional boron ion doping during plasma dissociation that may induce artificial reductions of *k* value on n-type substrates is alleviated by employing a remote microwave plasma process. Moreover, the adoption of low growth rate processes for ultralow-*k* aBN deposition is found to be critical to provide for the superior mechanical strength and high density, and is attributed to the formation of hexagonal ring stacking frameworks. These results pave the way and offer engineering solutions for new ultralow-*k* material introduction into future semiconductor manufacturing applications.

First published: 16 May 2022; https://doi.org/10.1002/admt.202200022

In this work, Annealsys laboratory has developed an amorphous boron nitride deposition recipe on 2-inch Si wafers using borazine precursor and vapor draw source on a Direct Liquid Injection CVD (DLI-CVD) machineMC-050. By employing remote microwave plasma, the deposition temperature could be as low as 370°C while keeping a dense material. The gas used in the process were found to be critical in achieving good B:N ratio (XPS: 0.84-1.12), and low dielectric constant *k* (@100 kHz: 2.22, @10^{14} kHz: 1.98). The results on Annealsys' samples were amongst the best in this work with excellent density (2.3 g/cm^3) and Young modulus (>100 GPa).

This success was made possible using the multi process capabilities of the MC-050 2-inch R&D system that includes: DLI-CVD, DLI-ALD, Plasma Assisted DLI-CVD and ALD, RTP, RTCVD, etc.

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