

# Nanocluster Luminescence, Structure, and Charge Trapping in ICP CVD $\text{SiC}_x\text{N}_y$ Films

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Hydrogenated amorphous silicon carbide ( $\text{SiC}_x$ ) and silicon nitride ( $\text{SiN}_x$ ) have long been a material of interest due to their high hardness, chemical inertness, wide bandgap, luminescent properties, and tunable optical constants. With the incorporation of both carbon and nitrogen silicon carbonitride ( $\text{SiC}_x\text{N}_y$ ) is formed. Optical activity and charge trapping of carbon and silicon nanoclusters is dependent on the cluster host matrix, local interfaces and the thin film deposition process. So, the increased compositional parameter space of this ternary compound allows for increased control of the optical and electronic properties of  $\text{SiC}_x\text{N}_y$  thin films. In this work the luminescent and charge trapping properties of amorphous, hydrogenated,  $\text{SiC}_x\text{N}_y$  thin films deposited by inductively coupled plasma chemical vapour deposition (ICP CVD) are examined.

Amorphous  $\text{SiC}_x\text{N}_y$  films of varying composition were grown by ICP CVD. The film composition was controlled by varying the process gas flow rates of  $\text{SiH}_4$ ,  $\text{CH}_4$ ,  $\text{N}_2$ , and Ar. Immediately prior to deposition the silicon substrates were subjected to a 90 second HF acid dip, and a 30 minute, in situ Ar plasma clean to remove the native oxide layer. ICP CVD depositions were performed with a substrate heater temperature of  $300^\circ\text{C}$  and an RF power of 300W. Post-deposition thermal annealing at  $600\text{--}1200^\circ\text{C}$  under flowing Ar and Ar + 5%  $\text{H}_2$  ambient gases was used to promote clustering of excess carbon and silicon in the films as well as the passivation of defects at the nanocluster / dielectric interface.

Elemental compositions of the films were determined through Rutherford backscattering spectrometry (RBS) and elastic recoil detection (ERD) experiments. The results confirmed the presence of structurally significant amounts of silicon, hydrogen, carbon, and nitrogen, as well as oxygen contamination in the films grown via ICP CVD. Light emission from the films was investigated through ultraviolet-excited photoluminescence (PL) measurements performed using a 325 nm HeCd laser and through DC electro luminescence at up to 50V. Further examination of nanocluster structure was performed using high resolution transmission electron microscopy (HR-TEM) at the Canadian Centre for Electron Microscopy at McMaster University. Finally, 250nm thick aluminum contacts were placed upon the films to minimize diffusion and enable electrical characterization. Using a simple resistive model, trapped charge densities were estimated from room temperature capacitance-voltage (C-V) curves and correlated to nanocluster size and film composition.

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