Plasma enhanced chemical vapour deposited stable boron carbide films for thermal neutron detection and low-k dielectric applications

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Abstract. Stable boron carbide films with tailorable composition and density have drawn significant attention for multifaceted applications. In this work, we report the fabrication of plasma assisted chemical vapor deposited optimised stable boron carbide films for both neutron detection and low-k dielectric applications. The effect of plasma assisted substrate self-bias and reactive gas ratio on the properties of boron carbide films are investigated to achieve the most stable phase of boron carbide with composition close to B_4C. The films deposited below 100 V and above 180 V substrate bias were found to be unstable due to presence of boron oxide related impurities as confirmed from synchrotron radiation-based X-ray photoelectron spectroscopy measurements and Fourier infrared transmission spectroscopy techniques. Furthermore, a novel single-step methodology has also been established for the conformal deposition of stable boron carbide films on n-type (111) silicon substrate as well as on 25 μm deep Si trenches for 3D neutron detector applications. Cross-sectional scanning electron microscopy analysis has confirmed the nearly complete filling of the trenches by boron carbide. In addition, the correlation between density and the dielectric property of these Boron carbide film-based devices are established using X-ray reflectivity and impedance spectroscopy measurements. The low-k values ranging between 2.1 to 3.9 have been achieved by varying the substrate self-bias between 100 to 260V. The findings presented in this study demonstrate the developed process for stable and conformal deposition of boron carbide films targeting neutron absorber layer and low-k dielectric material applications.

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