Boron-carbon thin films deposited via plasma enhanced atomic layer deposition (PE-ALD)

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Boron carbide (B_xC) finds diverse applications due to its superior hardness, high neutron absorption, and semiconducting nature. Magnetron sputtering [1], and high temperature (≥ 1000 °C) chemical vapor deposition (CVD) are the conventional processes to obtain boron carbide thin films. CVD involves boron hydrides [2] or halides [3] as precursors along with dihydrogen or simple hydrocarbons. Such precursors come with challenges such as high toxicity and/or corrosive by-products. Furthermore, conformality and thickness control of these films is still a challenge. To overcome it, atomic layer deposition (ALD) appears as a technique of choice, however, B_xC has never been synthesized by this technique so far.
From triethylborane (TEB) and hydrogen gas (H_2) as precursors, amorphous B_xC thin films with atomic-level thickness control on Si (100) substrate using plasma-enhanced atomic layer deposition (PE-ALD) are successfully obtained. The use of hydrogen plasma to remove ethyl groups of TEB to deposit B_xC films at low substrate temperatures (≤ 200 °C) is demonstrated. It should be noted that in this process the expected by-products are non-toxic and non-corrosive.
Here, the influence of the deposition parameters on the film growth rate, composition and structure will be discussed. The ALD reaction temperature is being investigated between 80 °C and 300 °C alongside spectroscopic ellipsometry. Additionally, the pulse/purge of precursors is optimized to ensure a saturated self-limited surface reaction, and the role of H_2 concentration and plasma power in the composition and growth of the deposit is being explored.
In-situ optical emission spectrometry (OES) is also performed to detect and compare the intensity of hydrogen lines, and to look at species responsible for etching and deposition during the ALD cycle. The impact of plasma-activated hydrogen species (as a function of plasma power and H_2 concentration) on the morphology and B:C ratio of the deposits is preliminarily assessed via secondary electron microscopy (SEM) and energy dispersive spectroscopy (EDS), respectively. Moreover, surface-sensitive quantification and bonding information are obtained via time-of-flight secondary-ion mass spectrometry (ToF-SIMS) and ex-situ x-ray photoelectron spectroscopy (XPS).

References

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