TUNGSTEN DOPING INDUCED SUPERIOR MECHANICAL PROPERTIES OF HAFNIUM OXIDE FOR ENERGY APPLICATIONS

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Dedication

Dedicated to my friends and family who pushed me to always move forward, especially my mom, the biggest influence on my education and success.

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Abstract

Hafnium oxide, or hafnia, is a high temperature refractory material with good electrical, chemical, optical, and thermodynamic properties. The effects of dopants have been widely studied, especially after the discovery of ferroelectricity induced in hafnia thin films. While attractive and used in the opto-electronic, memory devices, and semiconductor industries, there is a lack in the literature on enhancing the mechanical properties of hafnium oxide, specifically through doping it with tungsten, another material of interest particularly for future high temperature device applications. Thus, this work aimed to grow hafnia thin films doped with varying amounts of tungsten. The samples were grown via radio frequency-controlled sputtering, with the hafnia sputtering gun kept at 100 Watts and the tungsten sputtering gun varying from 0-100 Watts to obtain varying tungsten concentrations. The films were then evaluated using grazing incident x-ray diffraction (XRD), scanning electron microscope imaging, nanoindentation, and contact angle measurements. The XRD results showed that the undoped sample exhibited the (-111) peak corresponding to monoclinic hafnia, as expected, and that the peaks at tungsten deposition powers of 50 Watts and above were amorphous. The SEM images showed this as well as a corresponding decrease in grain size until they became amorphous. Nanoindentation yielded a constant increase in hardness from 0 through 100 Watts, while reduced elastic modulus peaked at 40 Watts, decreased, and then tapered off at 80-100 Watts. Finally, contact angle measurements showed that the samples became increasingly hydrophilic as tungsten content increased as well.

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