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On the phase formation of sputtered hafnium oxide and oxynitride films

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Hafnium oxynitride films are deposited from a Hf target employing direct current magnetron sputtering in an Ar–O2–N2 atmosphere. It is shown that the presence of N2 allows for the stabilization of the transition zone between the metallic and the compound sputtering mode enabling deposition of films at well defined conditions of target coverage by varying the O2 partial pressure.
Plasma analysis reveals that this experimental strategy facilitates control over the flux of the O− ions which are generated on the oxidized target surface and accelerated by the negative target potential toward the growing film. An arrangement that enables film growth without O− ion bombardment is also implemented. Moreover, stabilization of the transition sputtering zone and control of the O− ion flux without N2 addition is achieved employing high power pulsed magnetron sputtering. Structural characterization of the deposited films unambiguously proves that the phase formation of hafnium oxide and hafnium oxynitride films with the crystal structure of HfO2 is independent from the O−bombardment conditions. Experimental and theoretical data indicate that the presence of vacancies and/or the substitution of O by N atoms in the nonmetal sublattice favor the formation of the cubic and/or the tetragonal HfO2 crystal structure at the expense of the monoclinic HfO2 one.

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