14:00~14:30

Phase transformation of the $Hf_{0.5}Zr_{0.5}O_2$ induced by pulse electric field during thermal annealing

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Abstract

High-k gate oxides have been the workhorse for the semiconductor industry in the last decades. Device scaling is one of the most important factors, while the film quality, taking $Hf_{1-x}Zr_xO_2$ (HZO) as an example, is often sacrificed during thickness reduction due to phase instability. Enhancement of phase uniformity of ALD-grown HZO requires (i) powerful analytical tools that can probe the chemical state and crystal ordering of the film, and (ii) new optimization processes based upon the understanding of the analysis.

We adopted an electric-pulse assisted (EPA) process during thermal annealing to optimize the HZO films. The EPA provides a degree of freedom to control charged vacancy by electrically stressing the film during annealing. As reported, the migration of oxygen vacancies plays an important role in film nucleation[1], and phase uniformity might be improved if the EPA is properly applied. We used synchrotron x-rays to conduct interface characterizations, with emphasis on exploring the (i) inter-relation between film's oxygen state and capping electrodes and (ii) phase transformation, while applying the EPA. The microscopic and macroscopic properties of the HZO were correlated by linking the synchrotron and the polarization-voltage (P-V) results. We present preliminary results of x-ray diffraction patterns versus EPA treatments. We obtained significant relocation of the peaks upon different EPA stressing voltages. It can be interpreted as the phase transition arising from the migration of oxygen vacancy. More characterizations such as x-ray photoelectron spectroscopy (XPS), is needed to further understand the interface reconstruction.

Reference: [1] Zhou, Y , et al. Comput. Mater. Sci. **167**, 143-150, (2019).