Along the ion incident direction, the surface ion track displays two distinct morphologies. In the first region, the groove is formed and typically bordered in both sides by a string of small nanodots. In contrast, as the incident ion penetrate deeper, the protrusions are formed. Interestingly, it was found that the feature of the protrusions is strongly dependent on the electronic energy loss. Combined with high-resolution transmission electron microscopy, we suggest that the formation mechanism of surface nanostructures on TeO_2 irradiated with SHIs under grazing incidence is attributed to Plateau-Rayleigh instability of nanofluid. More importantly, we propose that it also provides a unique experimental method, which could be used to validate the existing results of molecular dynamics simulation of the instability of nanofluids.

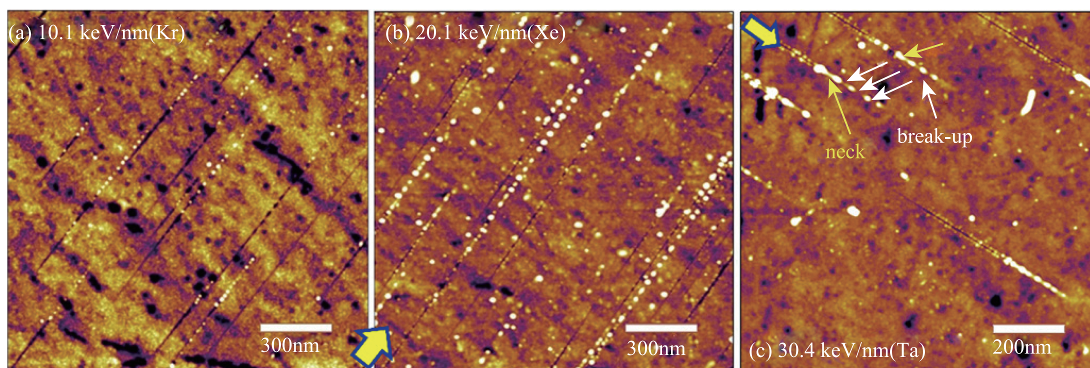

Fig. 1 (color online) AFM images of the irradiated TeO_2 by swift heavy ions under grazing (1°) incidence.

References

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* Foundation item: National Key research and Development Program of China (2022YFB3604001), National Natural Science Foundation of China (12075290, 12035019) and Youth Innovation Promotion Association of CAS (2020412)

5 - 16 The Reliabilities of HfO_2-Based Ferroelectric Devices under Swift Heavy Ion Irradiation

Li Zongzhen, Jiao Yang, Zhao Shiwei, Liu Yuzhu and Liu Jie

HfO_2-based ferroelectric films are considered to be one of the key materials for the development of next generation microelectronic devices. Up to now, HfO_2-based FeRAM devices show high immunity to proton and γ radiation[1,2]. However, to our best knowledge, the effects of swift heavy ions (SHIs) on HfO_2-based ferroelectric films were rarely reported and its mechanism is still missing. In this letter, we report the effect of SHI irradiation on the Zr-doped HfO_2-based (HZO) capacitors. The devices were irradiated by 16 MeV/u ^{181}Ta ions with electronic energy loss $(\mathrm{d}E/\mathrm{d}x)_\mathrm{e}$ of 49.3 keV/nm. The capacitance-voltage (C-V) and polarization-voltage (P-V) characteristics of the HfO_2-based metal ferroelectric metal (MFM) capacitors were measured using Keithley Semiconductor Parameter Analyzer. As shown in Figs. 1 and 2, we observed that the remanent polarization and relative permittivity of the capacitors decrease with increasing ion fluence, which is attributed to the enhanced pinning effects by the accumulation of defects and reduced orthorhombic phase fraction of the HfO_2-based films. We found that the coercive field remains unchanged with the increase of ion fluence, which validated the screening effect can be ignored. This work provides the possible physical mechanisms of SHI irradiation on HfO_2-based ferroelectrics, which is of significance for the space application of HfO_2-based ferroelectric random access memory.

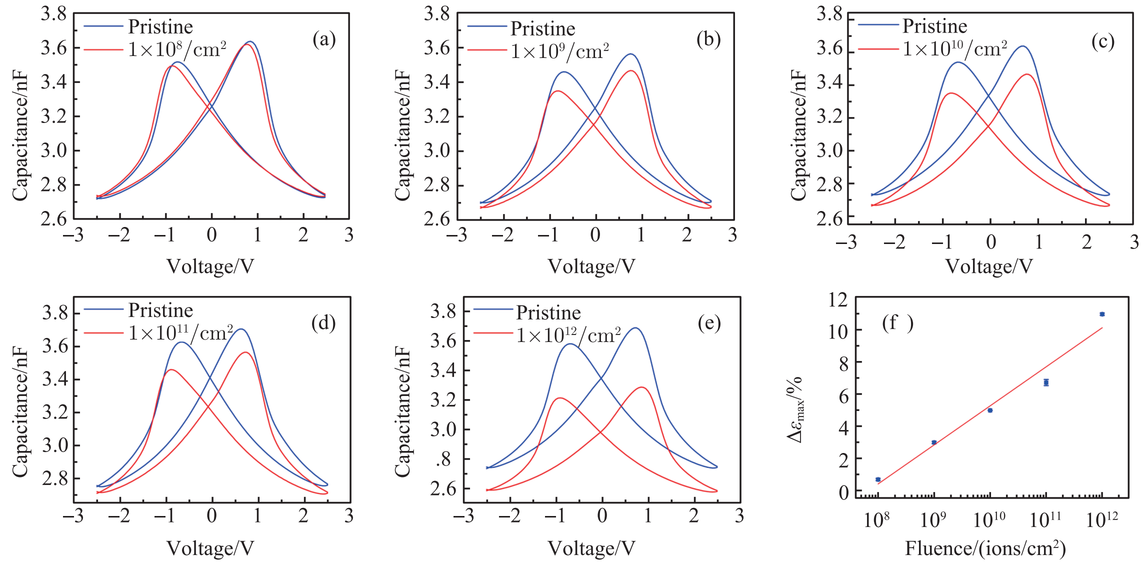

Fig. 1 (color online) The C–V characteristics of the HfO_2-based MFM capacitors before and after SHI irradiation: (a) 1×10^8, (b) 1×10^9, (c) 1×10^{10}, (d) 1×10^{11}, (e) 1×10^{12} ions·cm^{-2}, (f) The variation in the difference of permittivity before and after irradiation as a function of ion fluences. The solid line is the best fit of the experimental data.

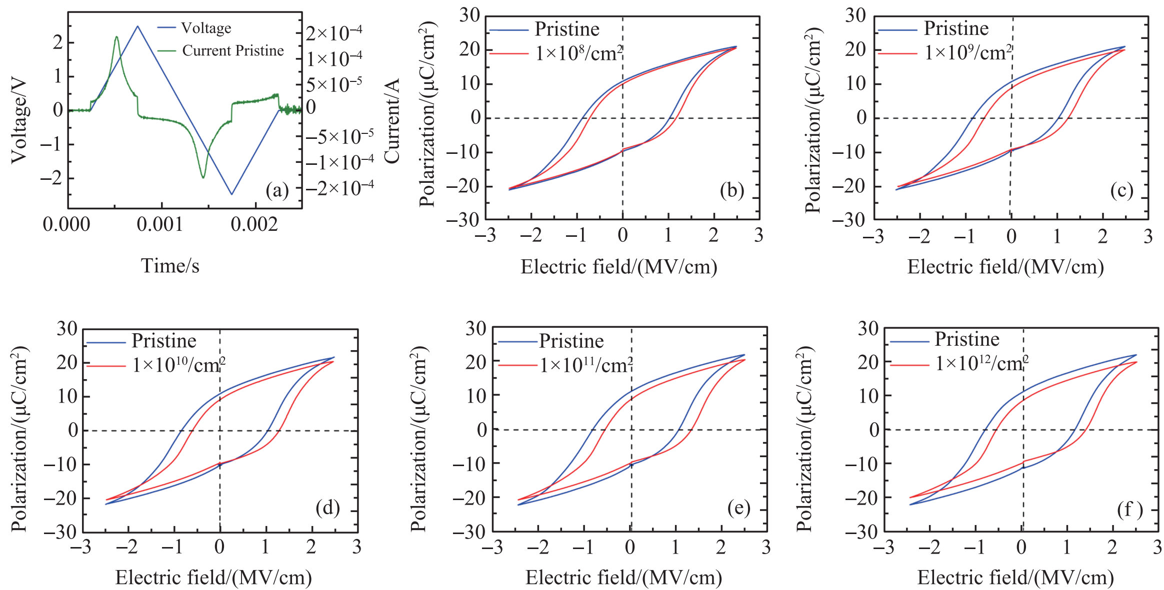

Fig. 2 (color online) (a) The voltage and current as a function of test time. The P–V characteristics of the HfO_2-based MFM capacitors before and after SHI irradiation, (b) 1×10^8, (c) 1×10^9, (d) 1×10^{10}, (e) 1×10^{11}, (f) 1×10^{12} ions·cm^{-2}.

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