Understanding and Control of Electronic Properties of Nanometer-thick Dielectric Films

Akira Toriumi
(The University of Tokyo, Graduate School of Engineering, Department of Materials and Engineering, Professor)

【Outline of survey】

The objective of this research is to build up principles for controlling electronic structures, electric and dielectric characteristics, and furthermore hetero-interface properties of nanometer-thick insulators. This will be applicable to any cases with insulators as well as to semiconductor devices. They are poorly understood even for simple MIM capacitors, and an understanding of the interfaces with insulators such as metal/insulator, semiconductor/insulator or insulator/insulator is particularly very poor.

So, on the basis of our knowledge, skills, and understandings on those materials we have so far developed in our lab., we will further develop and extend them. We are studying about not only direct experimental quantities but also interested in indirectly obtained properties such as effective mass in the tunneling, dielectric permittivity engineering mechanism, charge redistribution at the hetero-interfaces.

【Expected results】

Concerning semiconductor device applications, results of this research should directly contribute to performance enhancements of MIS capacitors, MIS FETs for advanced CMOS, and MIM for analogue devices or flash memories. This research will be progressed from the viewpoint of engineering of tunneling effects rather than just of observing them experimentally. Furthermore, the charge redistribution at the hetero-interfaces is related to the actual device control and will be investigated from a dipole layer formation viewpoint. These results can be extended to various semiconductor applications; particularly we are very interested in insulators on Ge.

【References by the principal investigator】

- A. Toriumi and K. Kita, *"Material Engineering of High-k Gate Dielectrics" Dielectric Films for Advanced Microelectronics*, M. Baklanov, M. Green and K. Maex (ed.), John Wiley & Sons, Ltd, 2007, pp.297-336.
- Y. Zhao, K. Kita, K. Kyuno and A. Toriumi "Higher-k LaYOx films with strong moisture resistance" Appl. Phys. Lett. **89**, 252905 (2006).
- Y. Yamamoto, K. Kita, K. Kyuno and A. Toriumi, "Structural and Electrical Properties of HfLaOx Films for an Amorphous High-k Gate Insulator," Appl. Phys. Lett. **89**, 032903 (2006).
- K. Tomida, K. Kita, A. Toriumi, "Dielectric constant enhancement due to Si incorporation into HfO2." Appl. Phys. Lett. **89**, 142902 (2006).
- K. Kita, K. Kyuno and A. Toriumi, "Permittivity increase of yttrium-doped HfO_2 through structural phase transformation", Appl. Phys. Lett. **86**, 102906 (2005).

【Term of project】 FY2007－2011	【Budget allocation】 38,400,000 yen (2007 direct cost)

【Homepage address】 http://www.adam.t.u-tokyo.ac.jp