# HX-PES Study of Buried Interface in Semiconductor Devices

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HX-PES experiments at SPring-8 beamlines have enough sensitivities and energy resolutions for practical use in development of semiconductor devices. We have applied HX-PES for development of Metal-Oxide-Semiconductor Field-Effect Transistor (MOSFET) with its advantages such as a large probing depth and excitations of deep core levels.

Metal gate electrode is a key technology to develop high-performance MOSFETs with sub-50 nm gate length, and a work function of the metal must be controlled for channel type to maintain low threshold voltage. Recently it is reported that fully-silicide gate electrode can realize dual work function by silicidation induced segregation of doped impurities at gate electrode/gate insulator interface [1], but the mechanism of work function modulation is still not clear. Then we have investigated chemical states of segregated impurities doped in fully-Ni silicide gate electrode by HX-PES.

B, P, As-doped $Ni_2Si$(50 nm) / $SiO_2$(2 nm) / Si(100) samples were pre-sputtered by $Ar^+$ ion to 5 nm of residual $Ni_2Si$ thickness in order to detect chemical states of impurities at buried interface without sputtering damage. HX-PES experiments were performed at BL47XU of SPring-8 with hard x-ray of 8 keV.

Fig.1 shows P1s spectrum with HX-PES and P2p spectra with conventional laboratory XPS for comparison, note the latter was acquired through the $SiO_2$ layer with backside-etched sample. P1s peak clearly shows small shoulder though P2p overlaps for broad Si2p plasmon-loss, so that P1s with HX-PES is better for detail analyses. P1s main peak and shoulder components are respectively assigned to P-Si and/or P-Ni bonding and sub-oxides. We consider that this sub-oxides with metal-P-O bond varies the interface dipole and modulates the work function of electrode.

[1] J. Kedzierski et al., IEEE International Electron Device Meeting 2003, p315 (2003).

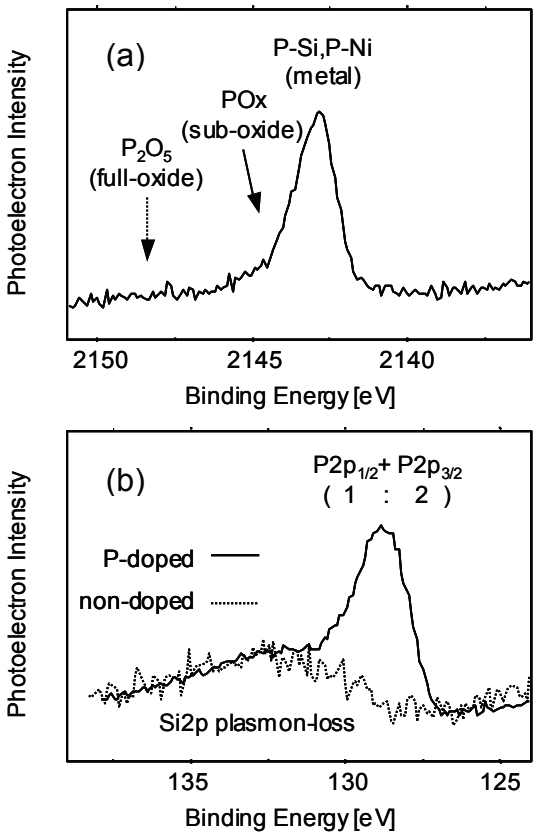


Fig.1. (a) P1s spectrum with HX-PES and (b) P2p spectra with laboratory XPS for P-doped $Ni_2Si/SiO_2/Si$.