論　文　内　容　の　要　旨

博士論文題目

Development of Empirical Potential Profile Model for Unusual Energy Separation of Subbands in Indium-adsorbed Si(111) Inversion Layer

（Si (111)反転層中のサブバンドの異常なエネルギー準位間隔に対する経験的反転層形状モデルの開発）

氏　　名　　NUR IDAYU BINTI AYOB

（論文内容の要旨）

In recent years, the thickness of the inversion layer (IL) reaches to nanometer scale due to the rapid downsizing of MOSFET. As a result, the study on the two-dimensional energy bands called subbands has attracted much attention since it is important for understanding the channel transport of the MOSFET. In this study, we investigated the potential profile by measuring the dispersion structure of the hole subbands (HSs) in Si(111)4×1-In surfaces.

Three ILs with different number of flash annealing (FA) and different dopant concentrations (DC) were made and the HSs were compared. We observed wider energy separations for the sample with less number of FA and higher DC. Furthermore, the measured HSs were compared with the calculated levels (CLs) by a Triangle Potential Approximation (TPA) theory. The experimental energy levels (ELs) by ARPES and the CLs were found to differ by 0.2 eV to 0.3 eV. This means that the band bending (BB) shape of the 4×1-In adsorbed Si(111) has a special profile that cannot be approximated by a triangular profile. Therefore, an empirical potential profile which reproduces the experimental ELs was newly developed.

The ELs that quantized in the potential profile were calculated by numerically solving the Schrödinger equation and we successfully reproduced the ELs for this potential within 0.0 to 0.02 eV accuracy. This result means that this potential is a reasonable BB profile for Si(111)4×1-In. Furthermore, based on the X-ray Photoelectron Spectroscopy (XPS) and Secondary Ion Mass Spectrometry (SIMS) results, the origin of this potential profile was believed to be the desorption of As atoms at the surface of Si substrate. It is concluded that a reasonable BB profile was derived from the ELs of HSs.

氏　名	Nur Idayu binti Ayob

（論文審査結果の要旨）

This thesis studies the potential profile at subsurface region of Si modified by flash annealing (FA) and metal adsorption. In recent years, the thickness of the inversion layer (IL) reaches to nanometer scale due to the rapid downsizing of MOSFET. As a result, the study on the two-dimensional energy bands called hole subbands (HSs) has attracted much attention since it is important for understanding the channel transport of the MOSFET. In this study, the change of the potential profile was investigated by measuring the dispersion structure of HSs in Si(111)4×1-In surfaces.

Three ILs with different number of FA and different dopant concentrations (DC) were made and the HSs were compared. We observed wider energy separations for the sample with less number of FA and higher DC. The measured HSs were compared with the calculated levels (CLs) by a Triangle Potential Approximation (TPA) theory. The experimental energy levels (ELs) by ARPES and the CLs were found to differ by 0.2 eV to 0.3 eV. This means that the band bending (BB) shape of the 4×1-In adsorbed Si(111) has a special profile that cannot be approximated by a triangular profile. Therefore, an empirical potential profile which reproduces the experimental ELs was newly developed.

The ELs that quantized in this potential profile were calculated by numerically solving the Schrödinger equation and we successfully reproduced the ELs for this potential within 0.0 to 0.02 eV accuracy. This result means that this potential is a reasonable BB profile for Si(111)4×1-In. Furthermore, based on the X-ray Photoelectron Spectroscopy (XPS) and Secondary Ion Mass Spectrometry (SIMS) results, the origin of this potential profile was believed to be the desorption of As atoms at the surface of Si substrate. It is concluded that a reasonable BB profile was derived from the ELs of HSs.

As described above this thesis has revealed the change of the subsurface potential profile experimentally by measuring their original method of HSs for the first time. Because this knowledge is fundamentally important to the basic science of semiconductor, the committee agreed that this thesis is worth as a PhD thesis for a Doctor of Science.