Poster

USE OF CONDUCTIVITY ON SILICON-ON-INSULATOR AS A PROBE OF MOLECULE-SURFACE INTERACTIONS

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The surface properties of semiconductor structures are dramatically affected by transverse electric fields, which can penetrate appreciably over sub-micron lengths. Crystalline films scaled to nanometer dimensions are thereby attractive platforms for detecting charged states present at a molecular interface, inducing band-bending. In these systems, surface conduction exhibits distinct behaviour from bulk transport. One critical property of silicon-on-insulator substrates (SOI) is that their top film thickness (50 nm<d<3µm) is comparable to or less than the space-charge width (~1µm) for light doping levels (10^{14}-10^{15}cm^{-3}). Therefore transport is ideally suited as a dynamic probe of events modulating the conductivity such as molecular physisorption[1], chemisorption[2], presence of surface dipoles, and occupation of electrically active gap states.

In this work, conductivity and Hall effect measurements in high vacuum (HV) environments and under ambient conditions have been used to monitor adsorption and reaction events on H-terminated SOI (111) and (100) surfaces. In ambient, the sheet resistance $R_s(t)$ and carrier density $n(t)$ of H-SOI was shown to degrade by 1-2 orders of magnitude in days, attributed to occupation of acceptor-like gap states formed during the early stages of oxidation. Surprisingly in addition to this increase, a thin water layer present was found to lower the resistance on n-type substrates[1].

Controlled adsorption of water confirmed that H_2O causes downward band-bending, inducing accumulation of electrons on n-type and an inversion layer on p-SOI. The latter effect was explored with a range of other gases. In particular, hole trapping molecules such as pyridine and ammonia have been found to mimic the action of a gate in a field effect transistor, biasing p-type surfaces into inversion[3,4]. A change in sign of the Hall voltage supports the formation of this inversion layer. Adsorption of toluene and thiophene vapors however, did not alter the resistance, indicating they weakly couple to electronic states of the silicon. These results demonstrate the potential of SOI substrates as platforms for studies of molecular adsorption and charge transfer effects at surfaces. The observations have significant relevance to the electronic properties of silicon nanowires, which are presently being studied for chemical sensing applications.

References:

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