Measurements of low field mobility in ultra-thin SOI *n*- and *p*-MOSFETs

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Silicon-on-insulator (SOI) technology is today a viable alternative to conventional CMOS due to its lower parasitic capacitance and higher radiation tolerance. In addition, if ultra-thin silicon films are employed, SOI technology offers ideal suppression of short channel effects with a virtually undoped channel, thus leveraging beneficial effects of low field mobility. Data reported so far show that electron μ_{eff} for channel thickness t_{Si} larger than about 50 nm features a universal, bulk-like behavior versus a suitably defined effective field, while experimental results reported for t_{Si} below 10 nm are not fully consistent.

Device processing started with Unibond SOI wafers featuring a 200 nm <100> Si film over 400 nm buried oxide. The Si film was thinned down to 9, 13, 20, and 60 nm nominal thickness through a series of oxidation followed by etching of the sacrificial oxide. After LOCOS, simplified processing of *n*-MOS and *p*-MOS devices was adopted: transistor channels were left undoped (*p*-type 10 $\Omega\cdot$cm resistivity), there was no LDD implant and no spacer formation. A specially designed MOSFET structure was used to measure low field mobility independently from parasitic resistance.

Our measurements shows that at high N_{inv}, μ_{eff} is largely insensitive to t_{Si}, consistent with μ_{eff} of low-doped bulk MOSFETs and it is remarkably larger than in heavily doped bulk devices due to the lower effective field. However, at relatively low N_{inv}, μ_{eff} clearly decreases with t_{Si}. A behavior similar to that of electrons is found for hole mobility, but the dependence on t_{Si} at small N_{inv} is weaker than for electrons. As for the physical interpretation of the results, we will show that the temperature dependence of μ_{eff}, measured between T = 225 and 375 K features a $T^{-1.4}$ dependence, which is close to the $T^{-1.7}$ behavior exhibited by phonon-limited mobility in bulk MOS. In addition we will show that our data are in quantitative agreement down to t_{Si} ~ 10 nm with numerical simulations by Gamiz and coworkers demonstrating that at small N_{inv} mobility is reduced because of increased phonon scattering in very thin quantum wells. As an additional, independent indication that the electronic structure within the channel is affected by t_{Si}, our measurements shows that threshold voltage (V_T) increases with decreasing t_{Si}. The subband quantization within the very thin layer is the explanation for this behavior.