Accurate prediction of the gate tunneling current for surrounding gate MOSFETs

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ABSTRACT

We report on the calculation of quasi-bound states in ultra thin film Surrounding-Gate (SG) MOSFETs and their impact on the direct tunneling current through the SiO_2 layer. For typical device parameters, the gate leakage in inversion is dominated by this tunneling component. However, if the eigenvalues of the closed system are used to calculate quasi-bound state tunneling current, then strong inaccuracies can arise [1]. To account properly for eigenstates of an open system, Absorbing Boundary Conditions (ABCs) should be included, which are commonly used for simulating waves in unbounded domains [2]. As one of those approaches for designing ABCs, Perfectly Matched Layer (PML) method has achieved great success for both linear and nonlinear wave equations due to their effectiveness. In this work we apply PML method in a 2D self-consistent Schrödinger-Poisson solver on a Surrounding Gate MOSFET for gate tunneling current computation (Eq. 1). This technique accounts for the wave function penetration into the gate, thus allowing a more accurate estimation of the electrostatic potential, quasi-bound states, charge and carrier lifetime [3]. Our results are compared with other models based on the computation of bounded states assuming a closed system.

$$ J = \frac{qkT}{\pi\hbar^2} \sum_{i,j} \frac{g_j m_\parallel}{\tau(E_{i,j}(m_q))} \ln\left(1 + \exp\left(\frac{E_f - E_{i,j}}{kT}\right)\right) \tag{1} $$

REFERENCES

[1] M. Karner, A. Gehring, H. Kosina, and S. Selberherr, "*Efficient Calculation of Quasi-Bound State tunneling in CMOS Devices*", Simulation of Semiconductor Processes and Devices, 2005. SISPAD 2005. International Conference on. Vol. Issue, 01-03 Sept. 2005 Page(s): 35-38.
[2] C. Zheng, "*A perfectly matched layer approach to the nonlinear Schrodinger wave equations*" Journal of Comp. Phys. 227 (2007) 537-556
[3] N. Yang, W. K. Henson, J. R. Hauser, J. J. Wortman, "*Modeling Study of Ultrathing Gate Oxides Using Direct Tunneling Current and Capacitance-Voltage Measurements in MOS Devices*", IEEE Trans. Electron Devices 46 (1999) 1464-1471
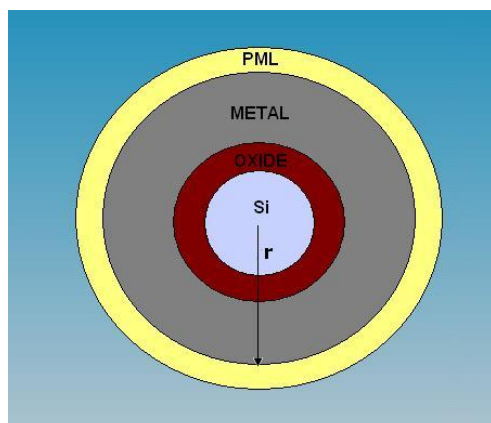

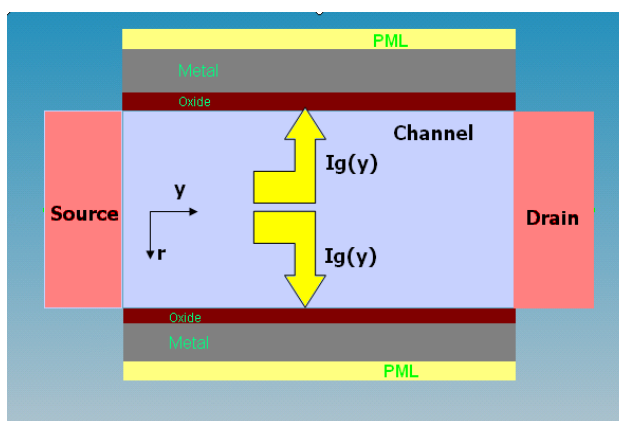Fig 1a. Scheme of the cross section of Surrounding a Gate Mosfet.

Fig 1b. Scheme of the longitudinal section of a Surrounding Gate Mosfet.