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Hysteresis and critical phenomena in silicon on insulator MOSFET's

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Abstract

An analytical model is proposed to account for the floating body effects in silicon on insulator MOSFET's. It enables a quantitative description of the hysteresis effects in the static characteristics and explains the correlation between the conductance and transconductance. Experimental data illustrate the occurrence of the negative conductance/transconductance and suggest that a critical phenomenon comparable to a second order phase transition takes place.

1. INTRODUCTION

Silicon on insulator (SOI) technologies and in particular SIMOX wafers have been greatly improved and now are being used for hardened and high speed integrated circuits. However, the modeling of some specific aspects and phenomena is still lagging behind the technological progress. In this paper, we propose an original approach of the floating body effects which are due to majority carriers generated by impact ionization. As they cannot be evacuated from the film because there is no body tie, the film potential increases and causes a reduction in the threshold voltage and a forward biasing of the source junction. The consequences of this positive feed-back are: kink in $I_D(V_D)$ curves [1], negative transconductance [2], hysteresis and loss of gate control.

2. MODEL

In order to derive realistic expressions for the channel conductance g_d and transconductance g_m in various regions of operation, we use (i) a rigorous expression of the threshold voltage V_{th} as a function of the internal body bias V_B and (ii) drain current equations holding from weak inversion to strong inversion regions. The continuity from weak to strong inversion enables a quantitative description of the $I_D(V_G)$ characteristics of Fig.1(a).