Impact of Focused Ion Beam Assisted Front End Processing on n-MOSFET Degradation

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Focused ion beam (FIB) systems are widely used for device modifications during the design debugging phase of integrated circuits (IC´s) development. Nevertheless, it appears necessary to further understand the interaction between the finely focused ion beam and IC´s to assure that these modifications do neither induce electrostatic discharge of the devices nor degradation due to FIB irradiation induced damage. We have investigated the focused ion beam interaction with n-MOSFET devices addressing irradiation damage related device degradation apart from charging effects.

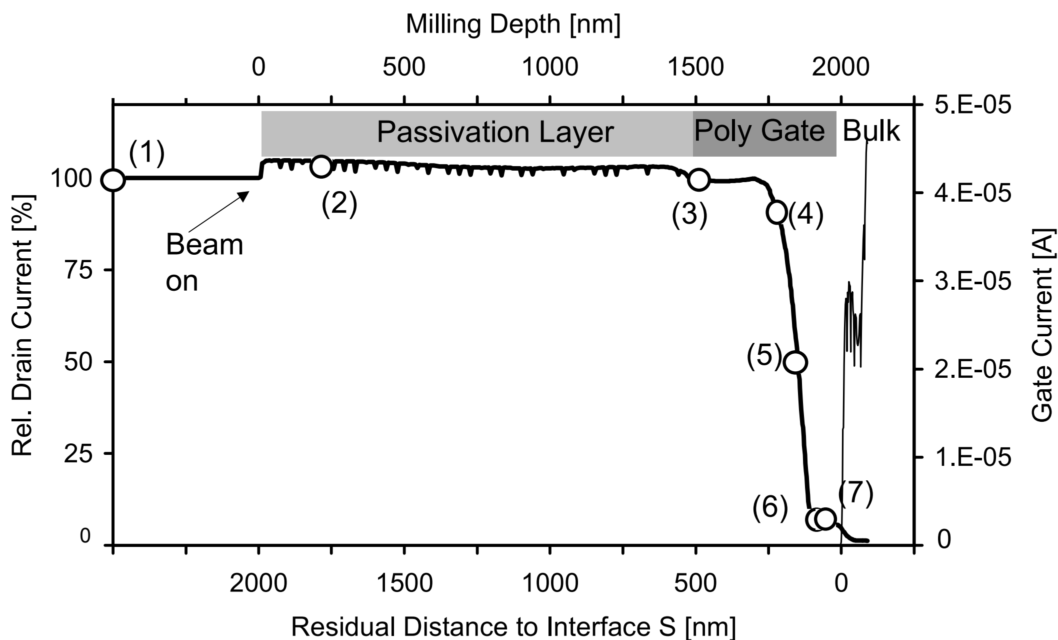

Fig. 1: Output and gate current of the n-MOS transistor vs. milling depth; bias conditions: $V_G = V_D = 3$ V; $V_S = V_{bulk} = 0$ V.

For the first time, monitoring of device parameters during ion beam exposure enables us to quantify the progressive nature of device degradation. By in-situ electrical sensing of the devices during focused ion beam milling, the impact on device parameters (I_{Dsat}, I_{Off}, and mobility) is studied. The FIB exposed MOSFET exhibits no damage related degradation as long as the milling is out of the reach of the active channel. Progressive degradation starts when long-range damage cascades extend into the channel region. The related damage can be attributed to mobility decrease in the channel region and has been quantified by a semi-empirical mobility model.

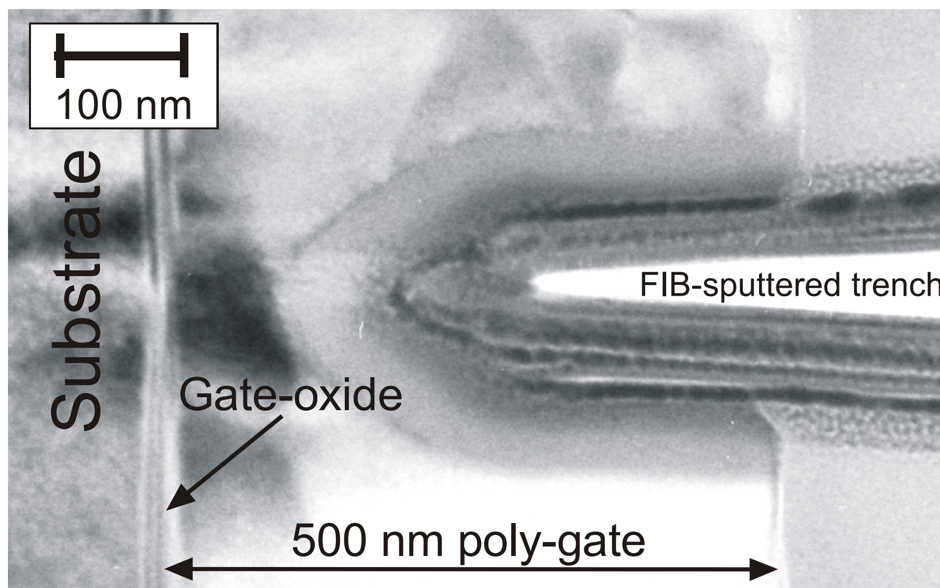

Fig. 2: Transmission electron microscope image of a transistor with a FIB milled trench reaching into the gate stack.