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pMOSFETs におけるチャネルへの歪印加によるランダム・テレグラフ・ノイズ低減の検討

A Study on Strain Induced Random Telegraph Noise Suppression in pMOSFETs

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Random telegraph signal (RTS) noise has been intensively studied in recent years due to their serious impacts on scaled non-volatile memories and logic circuits. RTS noise is normally believed to originate from carriers' trapping-detrapping via traps in the dielectrics (Fig.1). On the one side, current fluctuations are explained by the number fluctuation (Δn) model and the mobility fluctuation (Δμ) model [1], wherein the mobility fluctuation model illustrates good agreements with experiment data of p-type transistors. On the other side, current fluctuations are also correlated to substrate doping and explained by random dopant fluctuation (RDF) induced percolation path limitations. It is shown that random fluctuation dopant can seriously modulate current fluctuations ($\Delta I_d/I_d$) [2] and cause larger threshold voltage shifts (ΔV_{th}) [3].

In this work, firstly, impacts of channel doping concentration on RTS in pMOSFETs are studied. It is found that higher channel doping not only degrades $\Delta I_d/I_d$ and ΔV_{th_rts}. In fact, though RDF control means a lot for RTS noise suppression, channel doping is necessary in many cases. So, a method to decrease RTS noise in devices with inevitable channel doping might to more attractive. Based on the traditional mobility fluctuation model ($\Delta I_d/I_d \propto \Delta\mu_{eff}/\mu_{eff}$, μ_{eff} is carrier mobility), supposing that RDF related $\Delta\mu_{eff}$ are identical at a certain surface potential, μ_{eff} enhancement could minimize $\Delta I_d/I_d$ and suppress RTS noise. In previous work [4], it is known that higher hole mobility (μ_h) in pFETs can be obtained by scaling gate-to-STI edge spacing (X_g) to enlarge longitudinal compressive strain [5]. As shown in Fig.2, S_{vg} can be largely suppressed in pMOSFETs with higher hole mobility. Furthermore, even for single trap induced fluctuations, obvious suppression of $\Delta I_d/I_d$ and ΔV_{th_rts} are also confirmed. In conclusion, strain engineering, together with RDF control, is believed to an effective approach to suppress RTS noise.

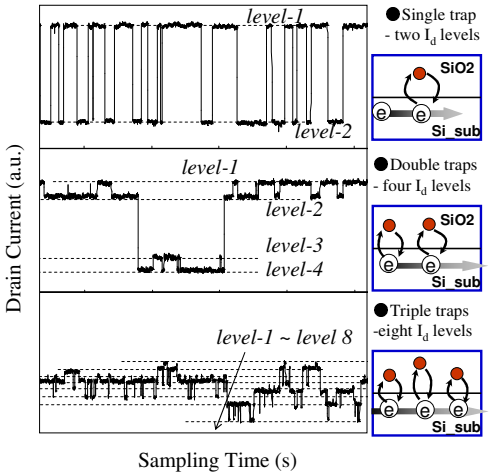

Fig.1 Typical random telegraph signal noise with single trap, double traps and triple traps.

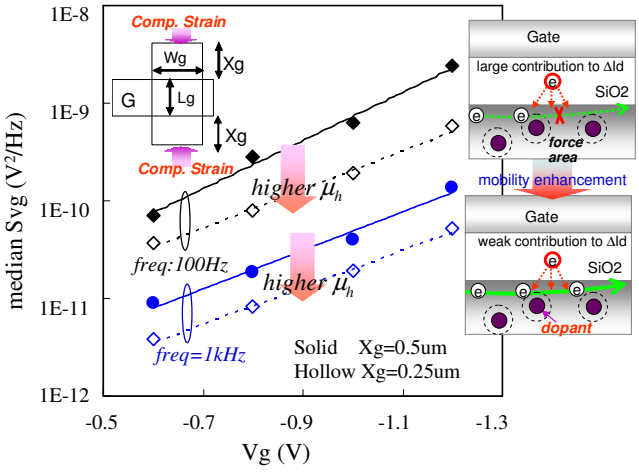

Fig.2 S_{vg} in pFETs of various X_g are compared. X_g scaling can improve hole mobility due to enhanced longitudinal compressive strain in the channel.

References: [1] K. K. Hung *et al.*, TED, 37(3), p654, 1990; [2]A. Asenov *et al.*, TED, 50(3), p.839; [3] A. Ghetti *et al.*, TED,59(2), p.309; [4] J. Chen et al., SSDM2012, p.825; [5] S.E. Thompson *et al.*, TED, 53(5), 2006, 2010