Noise Properties and Hetero-Interface Trap in SiGe-Channel pMOSFETs

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Introduction of a SiGe/Si heterostructure into Si MOSFETs is an effective approach for improving carrier mobility [1] and is a promising method for the construction of advanced, low-power, and high-speed Si CMOS devices. To effectively exploit the advantages of the SiGe/Si heterostructure, it is important to obtain a high quality heterostructure and its hetero-interface, and to clarify their influence to device characteristics. However, to our knowledge, there are very few (if any) reports on the direct measurement of interface trap density in such semiconductor heterostructures.

In this paper, firstly, we describe low-frequency noise (LFN) properties in SiGe pMOSFETs with a relatively wide range of Ge fraction of 0.2, 0.5, 0.7, and SiGe thickness of 2-14 nm (Fig. 1). We show that LFN in SiGe pMOSFETs can be lower than that in conventional Si pMOSFETs as shown in Fig. 2. Noise power at bias conditions showing the maximum linear transconductance is examined, where drain current is confirmed to flow mainly in the buried SiGe channel, but not in the surface Si channel. We found the universal relationship between the noise power and the maximum linear transconductance independent from SiGe thickness and Ge fraction as shown in Fig. 3, which suggests the importance of the electrical quality of the hetetro-interface.

Secondly, we show that the interface trap density in the SiGe/Si heterostructure can be successfully measured using a low-temperature charge pumping technique, without interference from the interface traps between the gate oxide and the semiconductor surface. Charge pumping current due to SiGe/Si interface traps and corresponding trap density as a function of SiGe thickness are obtained. Moreover, a good correlation between the measured interface trap density at the heterostructure and the LFN level in the current flowing in the SiGe-channel is obtained as shown in Fig. 4.

Reference

(1) J. Welser, J.L. Hoyt, S. Takagi and J.F. Gibbons: IEDM Tech. Dig., San Fransisco, 1994, p. 373.

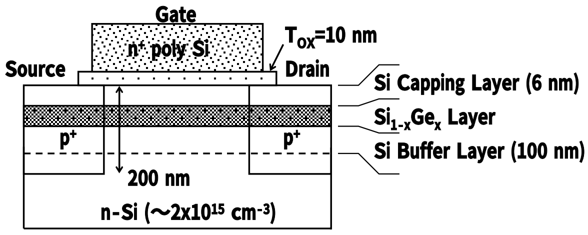

Fig.1 Schematic cross section of SiGe-channel pMOSFETs

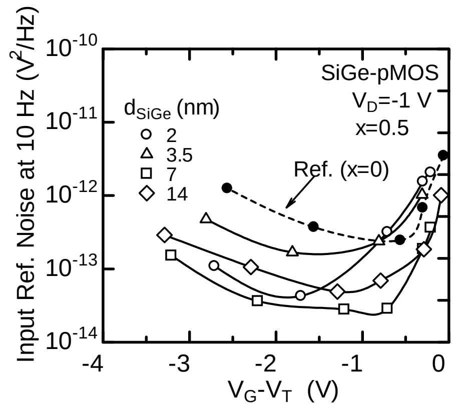

Fig.2 Noise power at 10 Hz as a function of V_G-V_T. Ge fraction x=0.5.

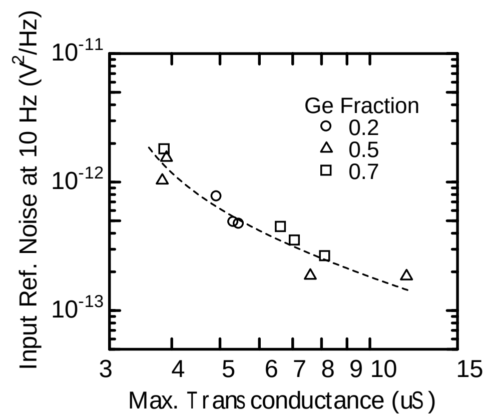

Fig. 3 Relationship between the noise power and the maximum linear transconductance.

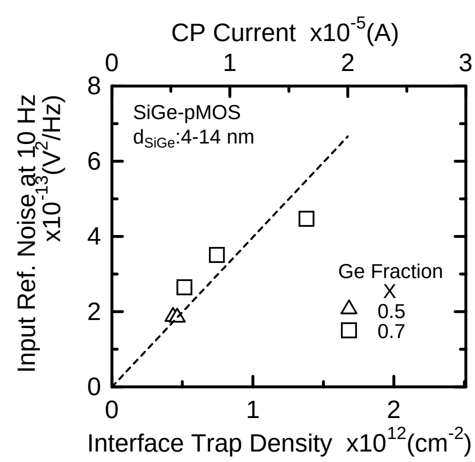

Fig. 4 Correlation between the neasured hetero-interface trap density and the low frequency noise level in the current flowing in the SiGe-channel