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Dopingless SiGe Transistors and Metal-Oxide-Semiconductor Ohmic Contacts

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創意重點

By adopting the charge-plasma concept and taking the relaxed SiGe as an example, this work elaborates the correlation of semiconductor band edges and source-drain metal workfunction for the electrical performance of p- and n-channel transistors based on numerical simulations. For a given high workfunction source-drain metal, it is found that the on-current, threshold voltage and off-current of p-channel devices increase monotonously with the Ge mole fraction. The trend of the n-channel devices, however, seems more complicated, but it can be interpreted by the band edge variation of SiGe alloy. Since the device performance is strongly affected by the metal-semiconductor contact resistance and the induced charge density, the requested high and low metal workfunction are benchmarked respectively for p- and n-channel Si and Ge devices. Experimental data of conduction of metal-semiconductor (MS) and metal-oxide-semiconductor (MIS) ohmic contacts has been demonstrated as well.

創意成果

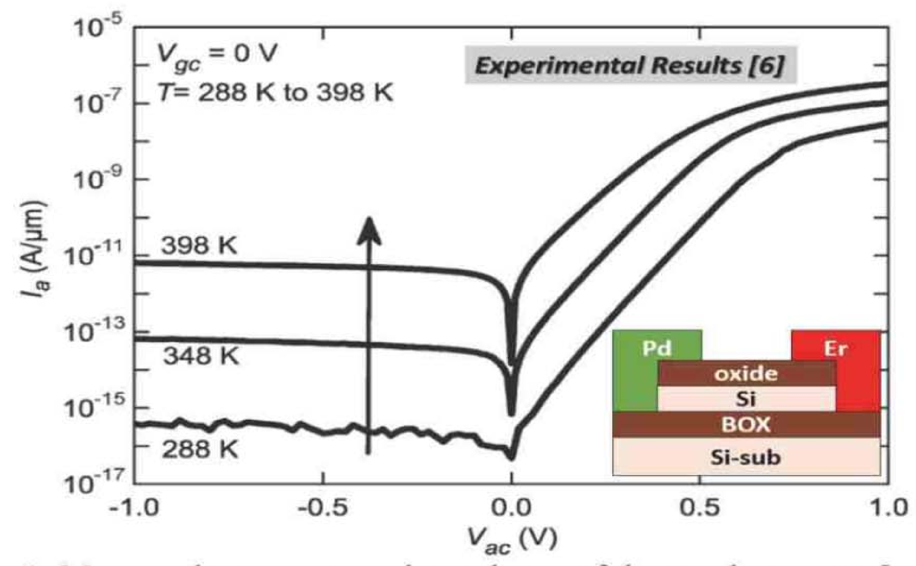

Fig. 1. Measured temperature dependence of the anode current I_a to anode-to-cathode voltage V_{ac} for the dopingless CP diode as shown by the inset.

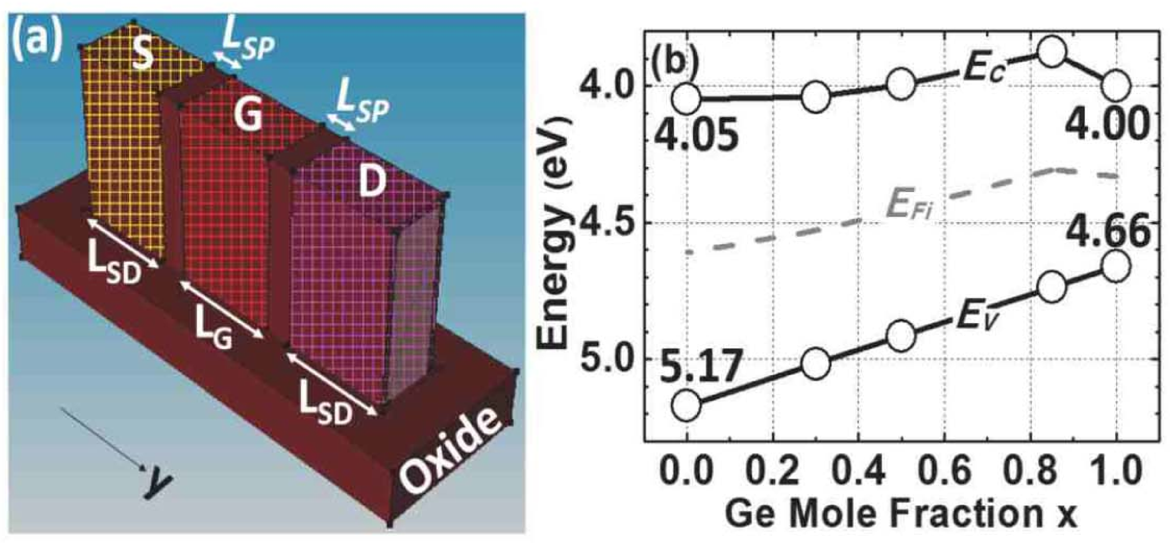

Fig. 2. (a): The simulated dopingless $Si_{1-x}Ge_x$ FinFET with a fin height H_{Fin} = 30 nm, a fin width W_{Fin} = 10 nm, gate and SD contact length L_G = L_{SD} = 20 nm, a spacer length L_{SP} = 5 nm and a gate effective oxide thickness of 1 nm. (b): The band edges of relaxed $Si_{1-x}Ge_x$ with respect to the vacuum level (0 eV) specified in simulations.

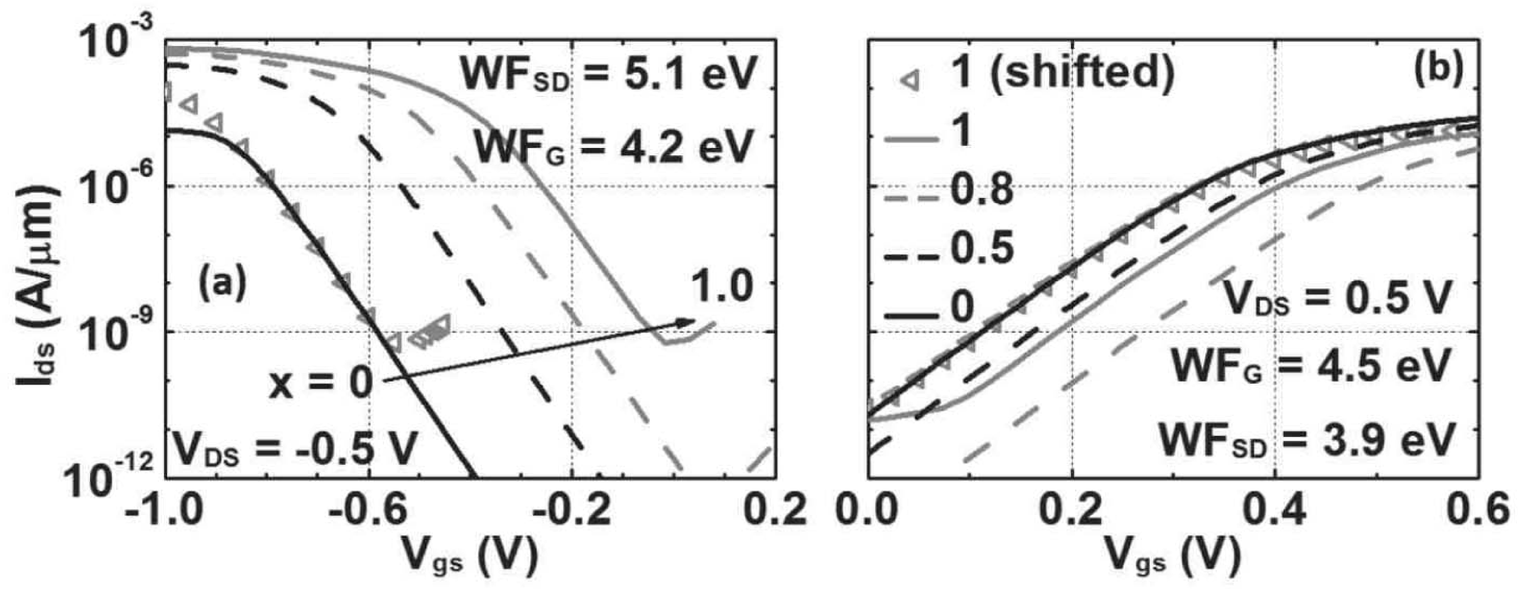

Fig. 3. Transfer characteristics of dopingless $Si_{1-x}Ge_x$ FinFETs for different x: (a) p-channel devices with WF_{SD} = 5.1 eV and WF_G = 4.2 eV. (b) n-channel devices with WF_{SD} = 3.9 eV and WF_G = 4.5 eV. The triangular symbols represents a shifted version of x = 1 to highlight the on-current difference. (a) and (b) share the same legend and vertical axis.

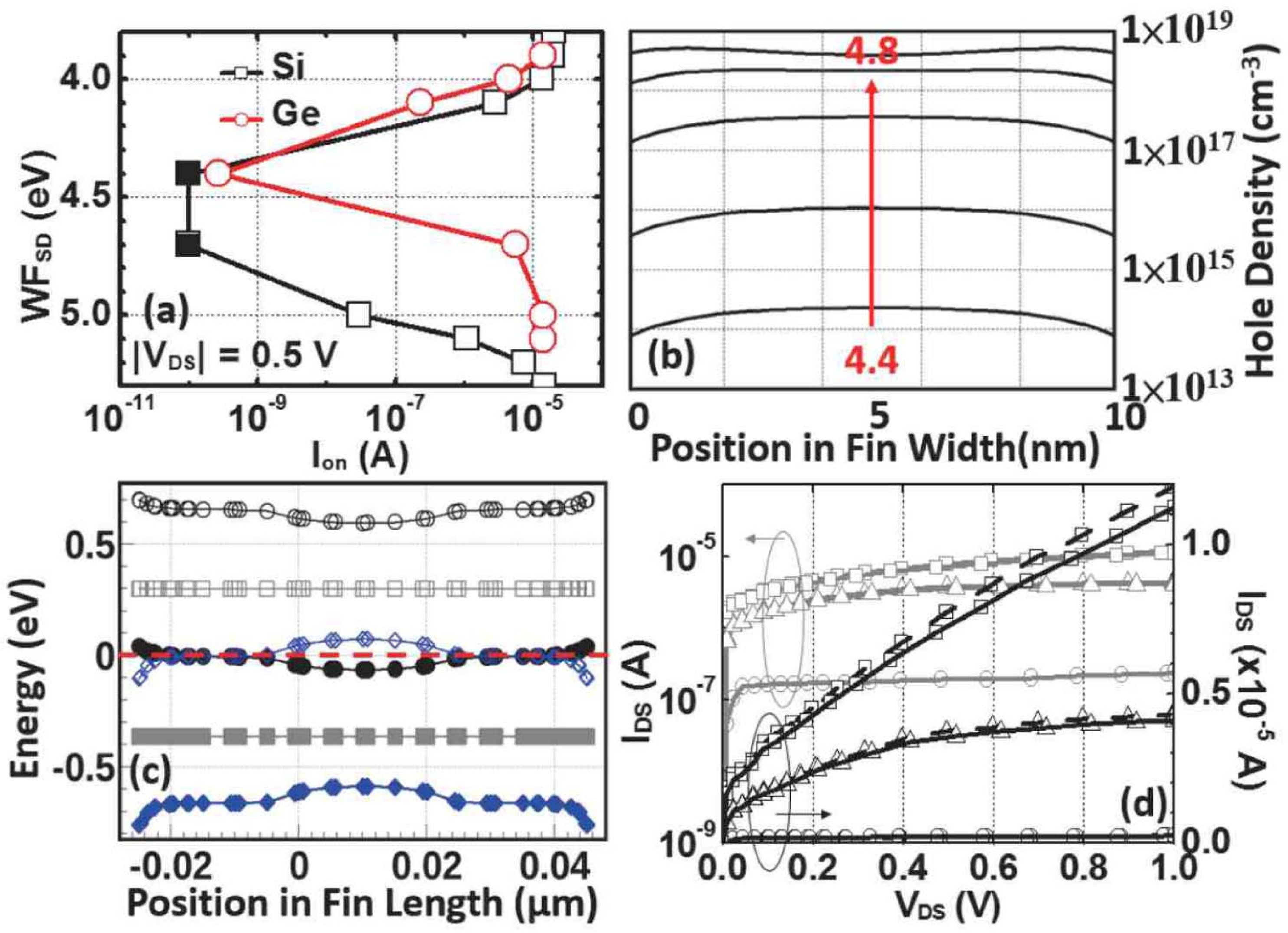

Fig. 4. (a) The on-current obtained with a gate overdrive of 0.5 V beyond a gate voltage at which the current is 0.1 nA for different WF_{SD}. (b) The induced hole density in Ge source-drain along the fin width with WF_{SD} = 4.4, 4.5, 4.6, 4.7 and 4.8 eV. (c) The Ge band edges with WF_{SD} = 3.9 (◊), 4.3 (□), 4.7 (○) eV and the mutual Fermi level in dashed line along the source-drain direction. Conduction and valence band edges are represented by open and filled symbols, respectively. Note that the calculation is done without the gate electrode (Fig. 2(a)) and V_{DS} = 0 V. (d) The electrical characteristics of an n-i-n Ge resistor with WF_{SD} = 3.8 (□), 4.0 (Δ), 4.1 (○) eV and oxide thickness T = 1.0 (solid), 0.5 (dashed) nm.

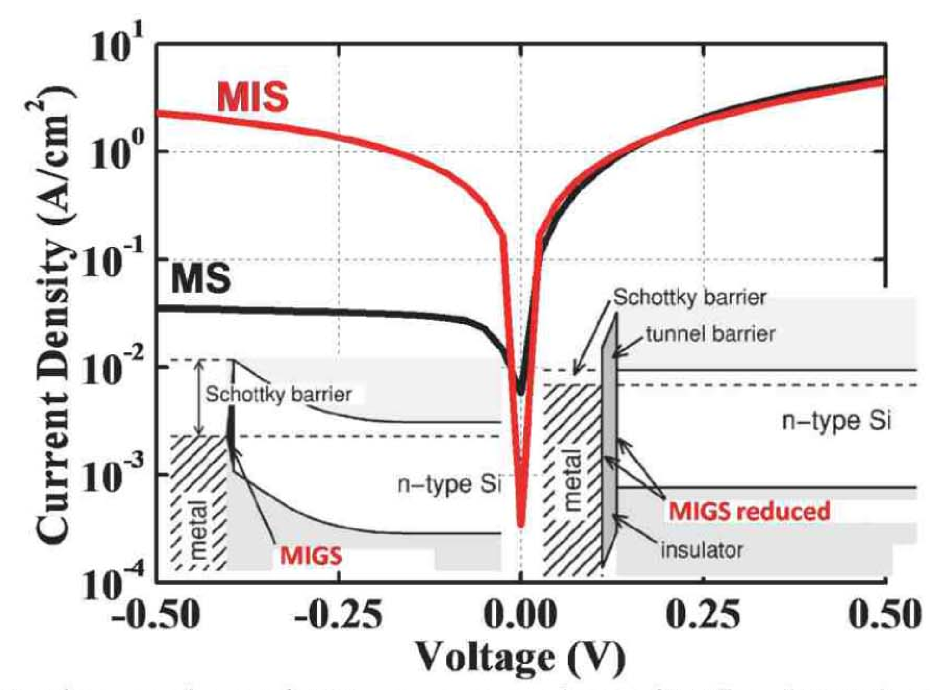

Fig. 5. The experimental I-V curve comparison of M-S and M-I-S contact.

創意心得

在研究奈米元件的過程中，我學會和知道了很多現在世界科技的趨勢以及奈米元件的知識，而且也必須付出額外的時間在研究和讀書上，比起其它大學生來的辛苦，但是成果是豐碩的。感謝我的指導教授的指導，以及家人的支持，也感謝中技社給予我的肯定和幫助，未來我會繼續在奈米元件領域持續精進，對社會和科技有所貢獻。