Corner Effects on Phonon-Limited Mobility in Rectangular Si Nanowire MOSFETs

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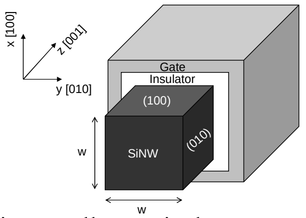
Introduction

The silicon nanowire (SiNW) MOSFET is one of the promising devices because of its good immunity for short channel effects.

Subband composition of local electrons is spatially dependent. Therefore, the geometric corner would affect the mobility in rectangular SiNW MOSFETs,

Based on spatially resolved mobility analysis, we reveal the corner effects on phonon-limited mobility

Methods[1,2)]



Self-consistent solution of 2D Schrödinger and Poisson equations were used for electron state calculation.

Intra- and inter-valley acoustic and inter-valley optical phonon scattering mechanisms were considered.

The Kubo-Greenwood formula was used for the mobility calculation.

We could spatially resolve the mobility by taking into account the subband composition of local electrons

Results and discussion

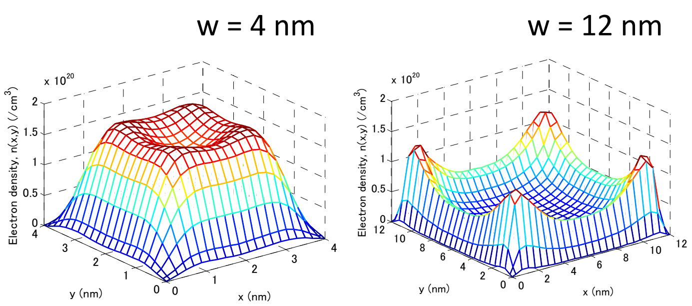
Parameters
$$\begin{cases} n_p = 10^{16}\ /\mathrm{cm}^3 & T = 300\ \mathrm{K} \\ t_{ox} = 1\ \mathrm{nm} & V_G = 1\ \mathrm{V} \end{cases}$$

Width dependence of phonon-limited mobility, μ_{ph}

w (nm)	N_{inv} (/cm²)	μ_{ph} (cm²/V·s)
4	1.1 x 10^{13}	557
12	1.1 x 10^{13}	725

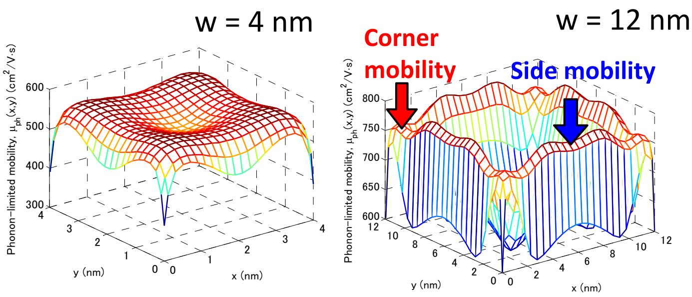
The small SiNW FET shows low mobility because of large wave function overlap.[1,2)]

Cross-sectional distribution of electron density



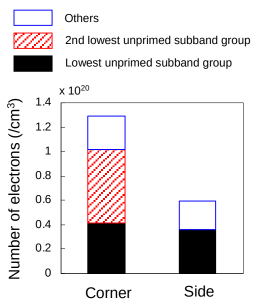
In w of 12 nm, the corner electron density is approximately twice as high as the side electron density

Cross-sectional distribution of mobility



In w of 12 nm, corner mobility is lower than side mobility.

Subband composition at corner and side

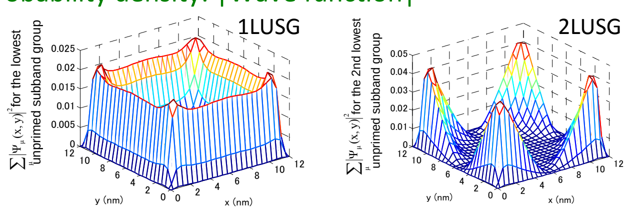


Mobility for each subband type

Subband type	μ_{ph} (cm²/V·s)
Lowest unprimed subband group (1LUSG)	898
2nd lowest unprimed subband group (2LUSG)	783

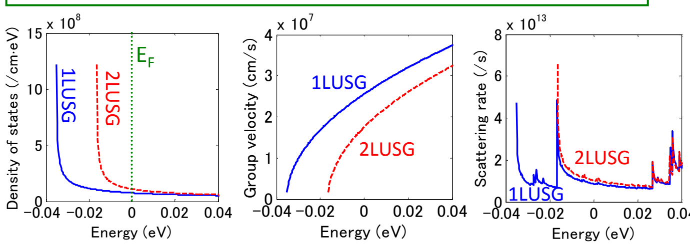
The low corner mobility is due to a large number of 2LUSG electrons with low mobility.

Probability density: |Wave function|²



Probability density for the 2LUSG concentrates at corner. Hence, at the corner, a large number of electrons occupy the 2LUSG.

Origin of the 2LUSG mobility lower than 1LUSG mobility



Low group velocity and high scattering rate of 2LUSG causes the low mobility of the 2LUSG.

Conclusions

The corner mobility was lower than the side mobility because of the large rate of the electrons occupying the 2nd lowest unprimed subband group (2LUSG) with the lower group velocity and high scattering rate.

1) R. Kotlyar, B. Obradovic, P. Matagne, M. Stettler, and M. D. Giles: Appl. Phys. Lett. 84 (2004), 5270.
2) S. Jin, M. V. Fischetti, and T.-w. Tang: J. Appl. Phys. 102 (2007), 083715.

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