Influence of biaxial stress on the electron transport properties at SiO_2/4H-SiC interfaces

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It is known that stress of lattice usually causes the modification of the effective mass and/or variations of the scattering rate, which affects the carrier transport. [1]. However, relationship between the biaxial stress at SiO_2/4H-SiC interface and the electron mobility is still unclear. As we know, due to the potential disturbances induced by the lattice vibration, the stress-induced electron transport is mainly limited by phonon scattering. Thus, in this work, the phonon limited electron mobility was calculated based on the acoustic and optical phonon scattering.

The electron relaxation time was incorporated using a parabolic band approximation for isotropic systems, and the density of states mass defined as $m^*_{dos} = (m_{M\Gamma} m_{MK} m_{ML})^{1/3}$ for the directions ($M\to\Gamma$, $M\to K$ and $M\to L$). The phonon-scattered electron mobility was calculated in the stress relaxed 4H-SiC crystal using $\mu = \frac{e\cdot\langle\tau\rangle}{m^*_c}$, where $m^*_c = 2\left(\frac{1}{m_{M\Gamma}} + \frac{1}{m_{MK}}\right)^{-1}$ is the conduction-band effective mass of the in-plane ($M\to\Gamma$, $M\to K$), and $\langle\tau\rangle$ is the average relaxation time. Then, the electron mobility was calculated in the strained 4H-SiC using a strain value as $\Delta a/a = 1.5\%$ (Δa: the change in the lattice vector). Fig. 1 shows the Brillouin zone in the hexagonal plane for both relaxed case (Left) and strained case (Right). The conduction band minimum for 4H-SiC is located at point M of Brillouin zone. Although the biaxial stress is applied, the crystal symmetry does not change in the x-y plane when the surface is located at c plane. Consequently, the biaxial strain has no effect on lifting the band degeneracy, since the states are all on the x-y plane [2]. However, the band-gap reduction for biaxially strained SiC has been reported as $\Delta E_{gap} = -0.04eV$ for $\Delta a/a = 1.5\%$ [3]. Fig 2 displays the electron mobilities of relaxed and strained SiC as a function of temperature. A significant reduction in the electron mobility in strained SiC has been evident from the figure. Although the experimentally obtained strain value at the SiO_2/SiC interface is much smaller than 1.5%, yet the strain-induced potential disturbances might act as scattering centers to affect the electron mobility in Fig. 2[4].

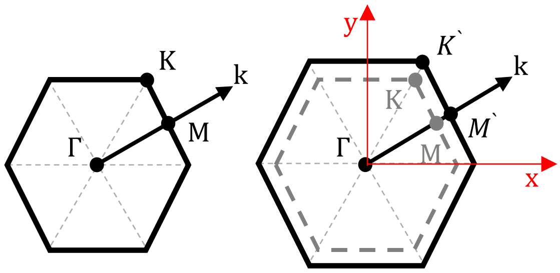

Fig. 1. First Brillouin zone and changes upon biaxial stress. Left: the equilibrium hexagonal first Brillouin zone and the special k-points Γ, M, K. Right: The first Brillouin zone after applying a biaxial stress of in-plane.

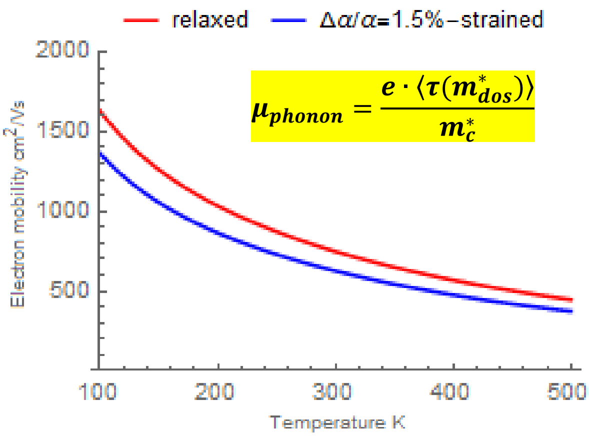

Fig 2 The phonon-limited electron mobility is stated as a function of the temperature of unstrained and strained.

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