# Physics and Engineering of CMOS Devices

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## Subband Structures (I)



#### Subband Structures (II)



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#### Subband Structures (III)



#### Wavefunctions





### Strain, Stress, Mobiliy





#### $E_{\rm C}$ Split and $\mu_{\rm e}$ Enhancement -Uniaxial <100> Stress-



In case of <u>uniaxial <100> stress</u>,  $\mu_e$  enhancement is accurately modeled by taking into account the split of E by the stress.

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#### *E<sub>C</sub>* Split and μ<sub>e</sub> Enhancement -Uniaxial <110> Stress-



#### **Effective Mass: Biaxial Stress**



Effective masses are almost constant under *biaxial stress*.

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### Effective Mass: Uniaxial <100> Stress



#### Effective Mass: Uniaxial <110> Stress



Transverse effective mass in 2-fold valleys changes greatly by uniaxial <110> stress.

✓  $m_{\mathrm{T},\perp}$  increases as tensile strain increases.

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#### **Mobility Enh. Vs Strain**



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## Quantum Confinement Effects and Mobility Enhancement

#### Subband Structure in Ultrathin-body SOI MOSFETs



K. Uchida, IEDM 2001, p633. Physics and Engineering of CMOS Devices, Ken Uchida, Tokyo Tech, July 8, 2009





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#### T<sub>SOI</sub> Dependence of Phonon-Limited Mobility



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#### **Band Diagram of SOI MOS Structure**



S. Takagi, Jpn. J. Appl. Phys., 37 No. 3B (1998) p1289.

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#### **Experimental Evidence of Mobility Enh.**



Enhancement of mobility with a decrease in  $T_{SOI}$  is experimentally observed.

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#### SOI Thickness Fluctuation Induced

#### **Scattering**





Physics and Engineering of CMOS Devices, Ken UcKiddo et al, JEDM, 2002, p47.

#### SOI Thickness Induced Scattering (I)



#### SOI Thickness Induced Scattering (II)

