



Barrier Heights of High-k Gate Dielectrics on Si for Future CMOS Technology

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Why High-k Gate Dielectrics?

SiO₂ has been the choice as gate dielectric for MOS technology for more than 3 decades, because of its unmatched properties, but it must be replaced in a few years as its thickness shrinks below 1.5 nm because of the resulting excessive gate leakage current. High-k dielectrics (dielectrics with high permittivities), such as HfO₂ and ZrO₂, are most promising candidates for this application.

Why is Barrier Height Important?

The barrier height strongly affects the gate leakage current

Using I-V to Determine Barrier Height

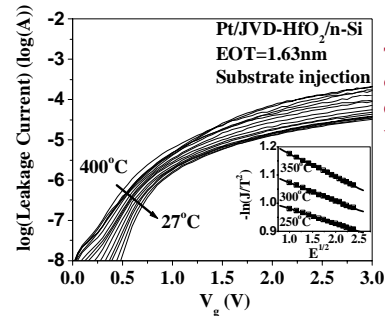
•Thermionic Emission Current Dominated Conduction:
 (Typical for Low Barriers and High Temperatures)

Use Temperature Dependent I-V to Determine the Schottky Barrier Height.

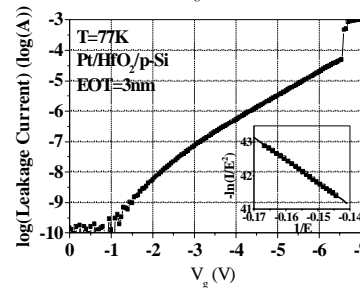
•Tunneling Dominated Conduction Process:
 (Typical for High Barrier and Low Temp)

Use Tunneling Theory to Extract Barrier Height and Effective Mass.

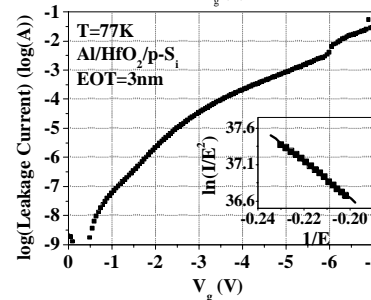
Examples of I-V Characteristics



Temperature dependence of I-V fits thermionic emission model very well, with a barrier height of 1.13 eV at the Si interface.

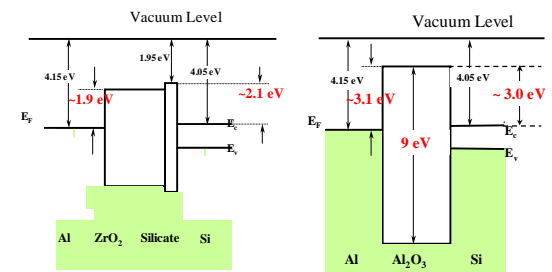
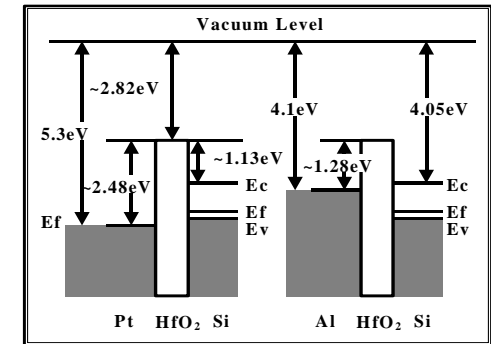
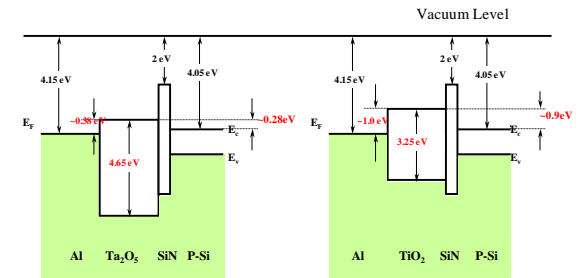


Injection current from Pt gate at 77 K fits the tunneling model very well



Injection current from Al gate at 77 K fits the tunneling model very well

Energy Band Diagrams Determined in this Work



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Al/ZrO₂/Silicate/Si

Al/Al₂O₃/Si