ENHANCED RESONANT TUNNELING IN MIIIS DEVICES FABRICATED WITH ULTRA THIN HIGH-K OXIDES
BY THE APPLICATION OF AN EXTERNAL MAGNETIC FIELD AND LOW TEMPERATURE

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In today's advanced logic technology, faster and more reliable Complementary Metal-Oxide-Semiconductor (CMOS) devices are required, and in the pursuit of these characteristics, ballistic transport is a feature that is always desirable, since no scattering phenomena will affect the performance of the device, thus, making it faster and more reliable because there will be no damage in the structure. However, ballistic transport is hard to obtain due to several phenomena masking this effect: thermal fluctuations at/above room temperature, poor-quality interfaces at the metal/dielectric/semiconductor structure, and of course, their corresponding scattering events during carrier transport whether from source-to-drain or substrate-to-gate directions. Recently, due to the nanometer scales in which new devices are fabricated, highly confined structures could promote the splitting of quantized Landau levels at the valence and conduction bands of the gate oxide, which in turn could promote ballistic transport. Nevertheless, another way to obtain ballistic transport is by the effect of resonant tunneling.

In this work, Metal-Insulator-Insulator-Insulator-Semiconductor (MIIIS) structures were fabricated using a combination of three ultra-thin high-k materials as gate oxides and in which their energy band-offsets are used as triangular quantum wells for energy level quantization in order to promote resonant tunneling phenomena. In particular, a stack of $\text{Al}_2\text{O}_3$/HfO$_2$/Al$_2$O$_3$ of 2nm/1nm/2nm respectively deposited by Atomic Layer Deposition (ALD) was used in order to promote the resonant tunneling due to the difference between the bang gap of these materials and because of the offset with n-Silicon. After fabrication, devices were electrically characterized in order to measure the carrier transport properties and correlate them with their conduction mechanisms. Proof of resonant tunneling was found due to the existence of a Negative Differential Resistance (NDR) zone. Afterwards, an external magnetic field was applied at low temperature (°77 K) directly to the structures in order to promote quantization of Landau levels, thus enhancing the resonant tunneling effect.

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