Investigation of the Nonlinearity Properties of the DC I-V Characteristics of Metal- Insulator-Metal (MIM) Tunnel Diodes with Double-Layer Insulators

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INTRODUCTION

Metal-insulator-metal (MIM) diodes may play an important role in the future CMOS-compatible, high-speed infrared sensor applications. The different properties of the I-V curve are of great interest in these uses.

The DC I-V curve of single-insulator-layer MIM diodes is treated in several theoretical papers in the literature [1-2]. There exist also numerous experimental studies on the DC I-V curve of single-insulator-layer MIM diodes [2, 5-6].

Up to now, there have been neither numerical results nor experimental papers published on double-insulator-layer MIM diodes yet. The present paper reports and discusses simulation results on the DC I-V curve of MIM diodes with double insulator layer.

PROBLEM FORMULATION AND SIMULATION ALGORITHM

The assumed potential profile of the double-insulator-layer MIM diode without applied voltage is depicted in Fig. 1. The value of the current density for a given value of the external voltage is then determined using the algorithm described in [3]. This very simple quantum transport model is based on the scattering of the electron wave function by a spatially varying potential. The tunneling probability of the electrons is determined by solving a space-discretized single-electron Schrödinger equation. The so called Quantum Transmitting Boundary Method (QTBM) [4] is applied when solving the equation.

SIMULATION RESULTS AND DISCUSSION

The R_D resistance and the $2m$ quality factor of the diode are examined as a function of five diode parameters. These quantities can be obtained from the different derivatives of the DC I-V curve.

The diode parameters are the total thickness of the insulator layers (L), the ratio of the thickness of the first insulator layer to the total thickness (r_d), the ratio of the relative dielectric constants (r_ε), the average work function (ϕ_0) and the asymmetry factor of the work functions (α).

The simulation results are shown in Fig. 2-6. In each of the diagrams, three of the five diode parameters are kept constant, while the other two are considered as independent variables.

ACKNOWLEDGEMENT

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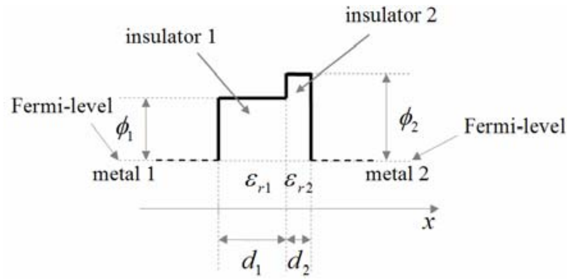

Fig. 1. Potential profile of the double-insulator-layer MIM diode without applied voltage

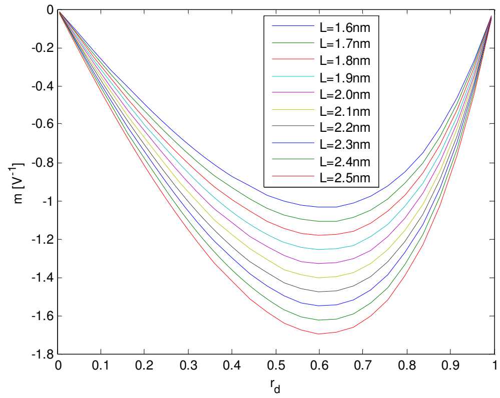

Fig. 2. m as a function of the thickness ratio r_d and the total thickness L

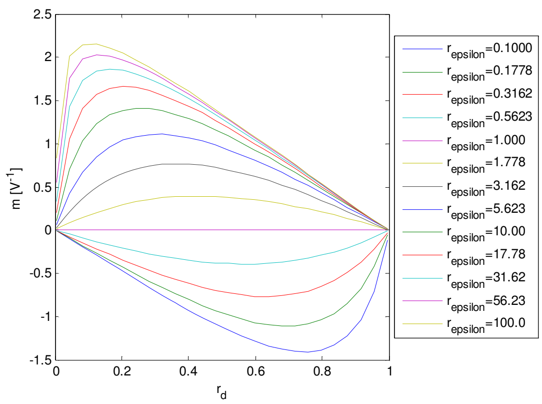

Fig. 3. m as a function of the thickness ratio r_d and the dielectric constant ratio r_ε

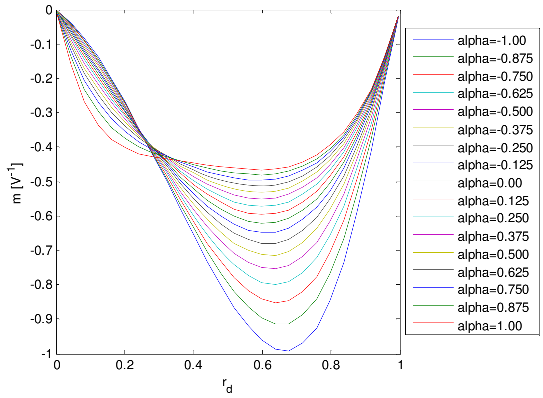

Fig. 4. m as a function of the thickness ratio r_d and the α asymmetry factor of the work functions

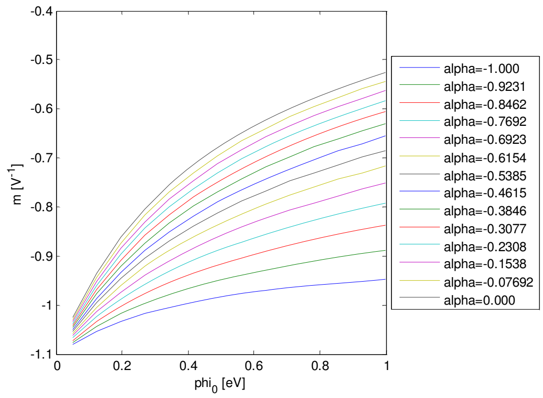

Fig. 5 m as a function of the average work function ϕ_0 and the α asymmetry factor of the work functions

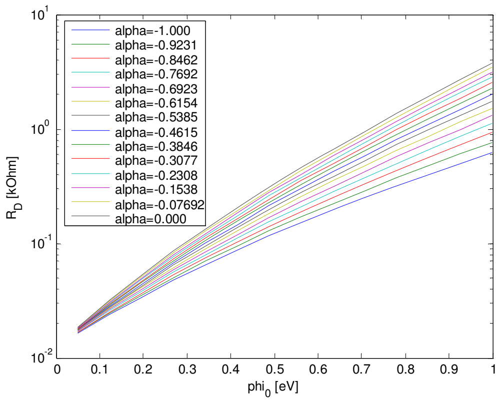

Fig. 6. R_D as a function of the average work function ϕ_0 and the α asymmetry factor of the work functions