TUNNELING AND MAGNETORESISTANCE IN FERROMAGNET/WIDE-GAP SEMICONDUCTOR/FERROMAGNET NANOSTRUCTURE

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DESCRIPTION

- The charge carrier transport model in the ferromagnet/wide-gap semiconductor/ferromagnet based on two-band Franc-Keine model (FKM) and phase function model is proposed.
- It is taken into account that tunneling barrier with the width d, which was founded by the band gap represents the energy band-gap. Its upper border is the bottom of the conduction band, and the bottom part is the top of the valence band. Inside this area the wave vector of the electron is an imaginary value.

MODEL

- The model takes into account bulk and interface barrier parameters and the image force potential and allows to include the potential relief of the wide-gap semiconductor.
- The principal feature of the phase functions method is the ability to find out the transmission coefficients.
- According to this method, only wave function variation, as a result of potential actions, is calculated rather than the proper wave function. This process is time-consuming for complex potentials. Besides, it is difficult to estimate the faults of results derived.

CALCULATION

- In FKM in order to calculate tunnel current density following equation is used

$$J(V)=\frac{4\pi q m_i}{h^3}\int_0^{\infty} dE\left[f_L(E)-f_R(E,V)\right]\int_0^{(\frac{m}{m_i})E} dE_P T_\sigma(E,E_P,V)$$

Using phase function method it is possible to calculate tunneling transmission for potentials of any complexity, including complex and potentials depending from energy

The tunneling transmission coefficient is

$$D(E)=\exp\left[\frac{1}{k}\int_0^d U(x)\left[b(x)\cos(2kx)-a(x)\sin(2kx)\right]dx\right]$$

- Where

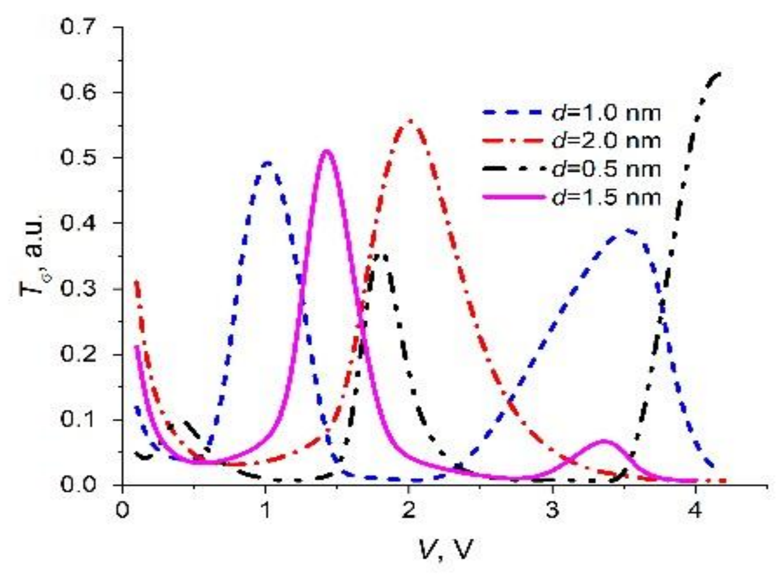
$$\frac{da(x)}{dx}=\frac{U(x)}{2k}\left[-\sin(2kx)-2b+(a^2-b^2)\sin(2kx)-2ab\cos(2kx)\right]$$

$$\frac{db(x)}{dx}=\frac{U(x)}{2k}\left[\cos(2kx)+2a+(a^2-b^2)\cos(2kx)-2ab\sin(2kx)\right]$$

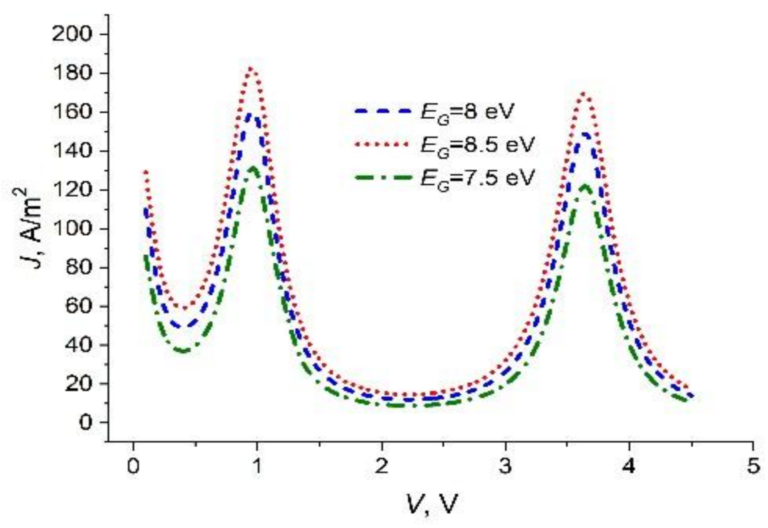
- Potential *U(x)* is

$$U(x)=\left(8\pi^2 m^*/h^2\right)\left(U_0-q\varphi(x)\pm V_s(x)\right)$$

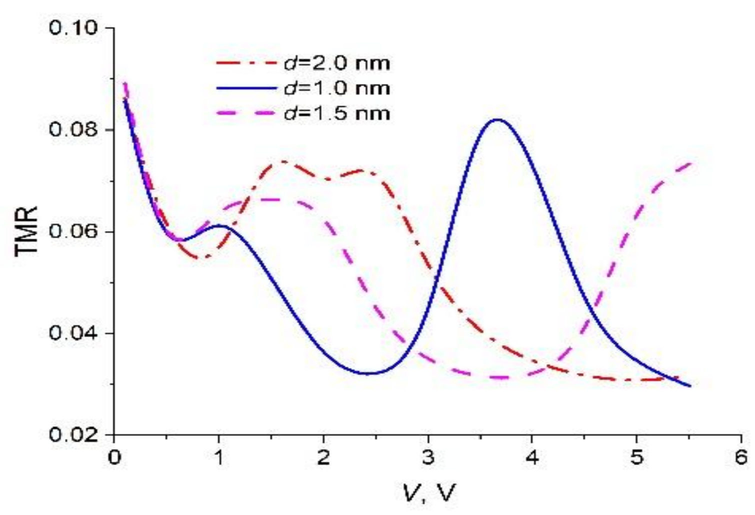
RESULTS



Transmission coefficient vs applied bias V: d=0.5-2 nm, EG=8 эВ.



Current density vs applied bias V: E_G =7.5-8 эВ, *d*= 2 nm.



TMR vs WGS thickness, *d*=1-2 nm.

CONCLUSION

- Tunneling coefficient, current density and TMR in FM/WGS/FM structure based on two-band Franc-Keine model and phase function method were calculated.
- It was shown that parameter oscillates at applied bias increasing. It explains by the presence of the alternate areas with the high and low tunneling transparency, where tunneling electrons layers exist. This area burst because of the changing of the Fermi quasi-layer position and generation of the additional tunneling channels in two-band wide gape semiconductor.
- Oscillation of the transmission coefficient sustain phase and amplitude changings, conditioned by the height and thickness of the WGS potential barrier. Represented dependencies of the TMR from the applied bias are explained by the combination spin polarization of the tunneling electrons and non-monotonous dependence transmission coefficient from energy.