

G. Giusi *et al.*, "Investigation on the Conduction Mechanisms in Metal-Base Vertical Organic Transistors by DC and LF-Noise Measurements," in *IEEE Transactions on Electron Devices*, vol. 64, no. 10, pp. 4260-4265, Oct. 2017.

doi: 10.1109/TED.2017.2738699

Abstract: Vertical organic transistors are a promising candidate to overcome the scaling limits of conventional horizontal organic field-effect devices. In this paper, based on the results of direct current (dc) and low-frequency noise (LFN) measurements, we propose a picture for the carrier transport in metal-base organic transistors in which transmission across the base is due to the combined action of both hot-carriers (HCs) and high-conduction paths (pores) in the metal base. Investigated devices employ pentacene and copper phthalocyanine as active layers for the emitter and collector regions, and a bilayer consisting of Au/MoO₃ as injecting electrode. The dc analysis highlights that the charge transport in the investigated devices is due to drift diffusion of the emitter-injected carriers in the highest occupied molecular orbital (HOMO) band and is dominated by HC injection, although conduction via pores increases and becomes not negligible at high base-emitter fields. The LFN analysis highlights the presence of two dominant and uncorrelated 1/f current noise sources, one located between base and emitter, due to the fluctuations of the not-transmitted HC current, and a second source located between collector and emitter, due to the fluctuations of the transmitted HC current and/or to the fluctuations of the current through the pores in the metallic base.

keywords: {1/f noise;gold;hot carriers;molybdenum compounds;organic field effect transistors;semiconductor device models;semiconductor device noise;l-f current noise sources;Au-MoO₃;HC injection;HOMO band;LFN measurements;base-emitter fields;carrier transport;charge transport;copper phthalocyanine;drift diffusion;emitter-injected carriers;high-conduction paths;highest occupied molecular orbital band;horizontal organic field-effect devices;hot-carriers;injecting electrode;low-frequency noise measurements;metal-base organic transistors;pentacene;transmitted HC current;vertical organic transistors;Atmospheric measurements;Current measurement;Integrated circuits;Particle measurements;Pentacene;Semiconductor device measurement;Transistors;Low-frequency noise (LFN);permeable base transistors;vertical organic transistors (VOTs)},

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Abstract: This paper presents the results of simulations using a model that describes constricted high current (>15 kA) vacuum arcs driven by a transverse magnetic field in a 2-D configuration (parallel rail electrodes). The simulations investigate a number of cases of practical interest for the use of vacuum interrupters. The influence of the electrode gap distance on the arc motion is discussed. It is found that faster arc velocities are obtained for larger gaps. For large gaps (ges5 mm), the Lorentz forces and pressure gradients acting on the plasma jets originating from the hot electrodes strongly affect the arc structure. The arc tends to expand on a longer distance and can efficiently preheat the next area of current attachment. The model also describes the jump of the arc over an electrically nonconductive part of an electrode (slit). This is possible due to the ability of the arc column to expand in the direction of motion and to prepare current attachment at a point beyond the slit. The characteristics of the jump depend on a function of the slit width, electrode gap, and current. Finally, the thermal effect on the electrode surface and the electrode bulk for an arc returning several times to the same position is investigated for a fixed DC current. The results show that the minimum surface temperature increases the first few times the arc returns, before stabilizing at a temperature given by the balance between the arc heat flow and the cooling by metal evaporation and conduction into the electrode.

keywords: {heat transfer;magnetic field effects;plasma simulation;vacuum arcs;vacuum interrupters;Lorentz forces;electrode gap distance;heat transfer;high current vacuum arc;plasma jets;pressure gradients;transverse magnetic field;vacuum interrupters;Heat transfer;moving arc;numerical simulations;transverse magnetic field (TMF) vacuum interrupter;vacuum arc},

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R. Chaujar, R. Kaur, M. Saxena, M. Gupta and R. S. Gupta, "TCAD Assessment of Gate Electrode Workfunction Engineered Recessed Channel (GEWE-RC) MOSFET and Its Multilayered Gate Architecture—Part I: Hot-Carrier-Reliability Evaluation," in *IEEE Transactions on Electron Devices*, vol. 55, no. 10, pp. 2602-2613, Oct. 2008.

doi: 10.1109/TED.2008.2003085

Abstract: This paper discusses a hot-carrier-reliability assessment, using ATLAS device simulation software, of a gate electrode workfunction engineered recessed channel (GEWE-RC) MOSFET involving an RC and GEWE design integrated onto a conventional MOSFET. Furthermore, the impact of gate stack architecture and structural design parameters, such as gate length, negative junction depth, substrate doping (*N_A*), gate metal workfunction, substrate bias, drain bias, and gate oxide permittivity on the device behavior of GEWE-RC MOSFET, is studied in terms of its hot-carrier behavior in Part I. Part II focuses on the analog performance and large signal performance metrics evaluation in terms of linearity metrics, intermodulation distortion, device efficiency and speed-to-power dissipation design parameters, and the impact of gate stack architecture and structural design parameters on the device reliability. TCAD simulations in Part I reveal the reduction in hot-carrier-reliability metrics such as conduction band offset, electron velocity, electron temperature, hot-electron-injected gate current, and impact-ionization substrate current. This paper thus optimizes and predicts the feasibility of a novel design, i.e., GEWE-RC MOSFET for high-performance applications where device and hot-carrier reliability is a major concern.

keywords: {CAD;MOSFET;hot carriers;impact ionisation;multilayers;work function;ATLAS device simulation;TCAD assessment;conduction band offset;device efficiency;drain bias;electron temperature;electron velocity;gate electrode workfunction engineered recessed channel MOSFET;gate length;gate oxide permittivity;gate stack architecture;hot-carrier behavior;hot-carrier-reliability evaluation;hot-electron-injected gate current;impact-ionization substrate current;intermodulation distortion;junction depth;linearity metrics;multilayered gate architecture;speed-to-power dissipation design parameters;substrate bias;substrate doping;Computer architecture;Design engineering;Doping;Electrodes;Electrons;Hot carriers;MOSFET circuits;Measurement;Permittivity;Signal design;ATLAS-2D;gate electrode workfunction engineered (GEWE);hot-carrier reliability;negative junction depth (NJD);recessed channel (RC) MOSFET},

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Abstract: The quantum efficiency associated with the internal photoemission of electrons over the Schottky barrier (of height ϕ_B) at the metal-Ge interface has been studied experimentally for several metals (Au, Cu, Ag, Pb, and Ni). A theoretical description of this mechanism has been developed in which we take into account the front and back optical absorptance, hot electron scattering, and multiple reflections of excited electrons from the surfaces of the thin electrode film. We have found it necessary to impose a modification of the Fowler theory of photoemission when applied to internal photoemission from thin metal films over a Schottky barrier. This modification relates to an enhanced photoexcitation within the metal films which is attributed in the present theory to a density of states which exhibits a peaked distribution in energy rather than the simple parabolic bands assumed by Fowler. It is clear from the present study that the majority of photoelectron excitation occurs from a small region of energy of the order of a fraction of an electron volt near the Fermi energy. The theoretical model presented here defines two important parameters: a hot-electron mean free path (L_e) and an energy (E_{ef}) given by the difference between the Fermi level and the effective conduction band minimum associated with the region of energy in the metal near the Fermi level where the electron distribution is strongly peaked. Values of L_e for Au is 550 Å, Ag is 570 Å, Cu is 450 Å, and Pb is 55 Å. E_{ef} for Au is 0.1 eV, Ag is 0.152 eV, Cu is 0.11 eV, Pb is 0.1 eV. The validity of this model is confirmed by the experimental finding that the parameters L_e and E_{ef} are independent of metal thickness.

keywords: {Infrared detectors;Photoemitting materials/devices;Schottky-barrier devices;Electrodes;Electron optics;Germanium;Gold;Optical films;Optical reflection;Optical scattering;Particle scattering;Photoelectricity;Schottky barriers},
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Abstract: The structures investigated consisted of three evaporated layers: a transparent indium-tin-oxide electrode on glass, gold-containing plasma polymerized thin film, and a small top electrode of Au or Al. A combined electroluminescence and transport analysis is carried out, and the emission process is investigated. It is noted that the implications of the emission process are important when studying the electrical transport and luminescence properties of polymeric thin films. On the one hand it can be used as a probe to detect the onset of hot electron conduction processes. On the other hand, care should be taken when looking at the electroluminescence due to the dielectric matrix; the mediation of the emission from the device by radiative plasmon decay at the electrodes must be considered when the current flowing through the structures is not negligible. The results confirm the fact that surface plasmons can be created in a metal-insulator-metal structure with no tunneling as the driving mechanism

keywords: {electroluminescence;filled polymers;gold;hot carriers;luminescence of organic solids;luminescent devices;metal-insulator-metal structures;polymer films;surface plasmons;Al electrode;Au electrode;Au filled polymer thin film;ITO electrode;InSnO;electroluminescence;evaporated layers;hot electron conduction processes;metal-insulator-metal structure;plasma polymerized thin film;radiative plasmon decay;surface plasmons;transport analysis;Dielectric thin films;Electrodes;Electroluminescent devices;Glass;Gold;Luminescence;Plasma properties;Plasma transport processes;Plasmons;Polymer films},
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Abstract: Modified high-density polyethylene (m-HDPE) is a candidate for high-voltage solid DC cable insulation. Based on the space-charge measurements on thick modified HDPE samples (1.5 mm), it was reported that modified HDPE contained relatively small amount of space charge and showed high breakdown strength. We measured space-charge distribution in thin m-HDPE samples (50 μ m) by using the laser-induced-pressure-pulse method in order to clarify effects of charge injection on the space-charge characteristics and electrical conduction. The samples with Au electrodes showed positive home space charge at room temperature but negative charge became dominant at higher temperature. These charges are due to injection from the electrode. The space-charge behaviour at voltage polarity reversal suggested that these space charges affected the breakdown characteristics. The samples with a semiconducting layer showed space-charge and conduction characteristics different from those with metal electrodes. The change was partly attributed to the diffusion of impurities during the hot-press process for applying the semiconducting layer

keywords: {charge injection;electric breakdown;electrical conductivity;polyethylene insulation;power cable insulation;space charge;breakdown strength;charge injection;electrical conduction;high-voltage solid DC cable insulation;hot pressing;impurity diffusion;laser-induced pressure pulse method;m-HDPE;metal electrode;modified high-density polyethylene;semiconducting layer;space charge;voltage polarity reversal;Breakdown voltage;Cable insulation;Charge measurement;Current measurement;Electrodes;Polyethylene;Semiconductivity;Solids;Space charge;Temperature},
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S. Srisophonphan and K. Jitkajornwanich, "Nearly Ballistic Electron Transport in an Out-of-Plane Nanoscale Defect-Void Channel," in *IEEE Transactions on Electron Devices*, vol. 65, no. 6, pp. 2601-2606, June 2018. doi: 10.1109/TED.2018.2824401

Abstract: Future nanoelectronics will require a high packing density of semiconductor devices so that electrons can be transported at speeds approaching their ultimate limit while operating at low power. Herein, we employ high-voltage pulses to create a nanoscale defect-void channel in an oxide to conduct an out-of-plane electron current from 2-D electron gas in a p-Si substrate to a metal electrode of metal-oxide-semiconductor structure. With this approach, we exploit the advantage of changes in the SiO₂/Si structure after oxide breakdown and carrier transport properties to increase device performance. The electrical characteristics of the two-terminal device indicate ballistic electron transport in the nanochannel, providing potential energy-efficient and high-speed (in the picosecond regime) applications for computing systems and logic circuits with low-cost fabrication. Space-charge-limited current models offer physical insights into the formation of nanochannels containing a combination of free space and dielectric solid. Hot carrier injection in the nanochannel also provides an understanding of the defect physics via atomic luminescence and localized surface topography, as well as substantial insights via optical emission spectroscopy and atomic force microscopy into how defects rearrange themselves locally when their electronic state changes.

keywords: {MIS structures;atomic force microscopy;ballistic transport;carrier mobility;electrical conductivity;electrodes;elemental semiconductors;hot carriers;nanoelectronics;nanostructured materials;semiconductor devices;silicon compounds;space-charge-limited conduction;2D electron gas;SiO₂-Si;ballistic electron transport;carrier transport properties;defect physics;electronic state changes;high

packing density;high-voltage pulses;low-cost fabrication;metal electrode;metal-oxide-semiconductor structure;nanochannel;nanoelectronics;out-of-plane electron current;out-of-plane nanoscale defect-void channel;oxide breakdown;p-Si substrate;semiconductor devices;space-charge-limited current models;two-terminal device;Dielectrics;Electric breakdown;Electrodes;Logic gates;Metals;Nanoscale devices;Solids;Ballistic transport;dielectric;electron emission;metal-insulator structures;space charge;vacuum electronics},
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Abstract: Recently, plasmonic effects of metal nanostructures have been intensively exploited to enhance the performance of organic solar cells (OSCs). The plasmonic-optical effects of localized surface plasmon resonances, scattering effect and propagating surface plasmon resonances, etc., are well recognized in considerably enhancing the active layer absorption. Besides, the improved electrical properties of OSCs by plasmonic-electrical effects have recently been reported to be of equal importance in enhancing the performance of OSCs through the introduction of plasmonic metal nanostructures into different layers of OSCs. In this review, the plasmonic-electrical effects of metal nanostructures-induced space-charge limit elimination, transfer of plasmonically excited hot carriers, and charge-accumulation effects would be briefly discussed. The mechanisms of each plasmonic-electrical effect including tailored transport path of charge carriers (electron and hole), reduced extraction barrier of carrier transport layer, and redistributed exciton generation in active layer for enhancing the performance of OSCs would also be studied simultaneously with the experimental and theoretical results. The promoted electrical properties of OSCs by the plasmonic-electrical effects and the future combination of plasmonic-optical and electrical effects would promisingly offer an alternative way to further improve the performance of OSCs.

keywords: {electron mobility;excitons;hole mobility;limited space charge accumulation;nanostructured materials;plasmonics;solar cells;space-charge-limited conduction;carrier transport layer;charge carrier transport path;charge-accumulation effects;electron transport;hole transport;metal nanostructures;organic solar cells;plasmonic-electrical effects;plasmonic-optical effects;plasmonically excited hot carriers;redistributed exciton generation;reduced extraction barrier;space-charge limit elimination;Absorption;Electrodes;Excitons;Gratings;Metals;Nanostructures;Plasmons;Organic solar cell;nanostructure;plasmonic-electrical effects;plasmonic-optical effects},
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Yasuhiro Tachibana, H. Y. Akiyama, Kazuya Umekita, Yasuhide Otsuka, Tsukasa Torimoto and Susumu Kuwabata, "Quantum dot sensitized solar cells," *2008 2nd IEEE International Nanoelectronics Conference*, Shanghai, 2008, pp. 160-165.
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Abstract: Metal sulfide (CdS or PbS) quantum dots were synthesized in nanoporous TiO₂ films for applications in solar energy conversion devices. Several electrolytes were investigated for the functioning redox activity in sandwich type regenerative solar cells, based on the quantum dots sensitized TiO₂ film. A high IPCE was attained by optimizing the polysulfide electrolyte composition. The CdS QD shows a higher IPCE, compared to PbS, related to an increased light harvesting efficiency when the number and size of the QDs intensified. In contrast, QD size dependence on the IPCE was observed for the PbS, likely resulting from the conduction band edge potential shift (associated with quantum size effect) relative to the TiO₂ conduction band edge, or the kinetic competition between the hot electron injection and the electron relaxation in the PbS conduction band. We also propose that an I₃⁻/I⁻ redox electrolyte, with NaSCN addition, can be employed to enhance the solar cell performance. SCN⁻ ions may attach to the QD surface forming a shell type structure to prevent the photocorrosion reaction, and act as an intermediate electronic state to induce the sequential step electron transfer reactions for the QD re-reduction.

keywords: {nanoporous materials;semiconductor quantum dots;solar cells;conduction band edge potential shift;hot electron injection;metal sulfide quantum dots;nanoporous films;photocorrosion reaction;polysulfide electrolyte composition;quantum dot sensitized solar cells;redox activity;sandwich type regenerative solar cells;sequential step electron transfer reactions;solar energy conversion devices;Electrodes;Kinetic theory;Nanoelectronics;Nanoporous materials;Photoconductivity;Photonic band gap;Photovoltaic cells;Quantum dots;Secondary generated hot electron injection;Solar energy},
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Abstract: To implement an electrically rewritable device for Read Mostly Memory applications, the structure of the FAMOS device is modified by incorporating an additional metal gate on top of the floating polysilicon gate and separated from it by a specially grown thermal oxide. Electrical erasure is accomplished by applying a positive voltage pulse to the metal gate. The "write" voltage has been lowered by using ion implantation. Reliability and charge retention are discussed and their impact on the design of the device is assessed. An empirical model for the conduction of oxide between the floating gate and the metal gate is developed and results are projected and compared with data obtained on the device.

keywords: {Degradation;Dielectric substrates;Electrodes;Emulation;Ion implantation;Microprogramming;Nonvolatile memory;Silicon compounds;Substrate hot electron injection;Voltage},
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Abstract: The molecular nature of most insulating solids of practical importance is emphasized. As a consequence of weak molecular interactions, charge transport through such materials occurs by tunnelling between localized molecular electron states. The energies of these states are modified by local polarization and this is particularly important at a metal electrode - molecular solid interface where charge transfer to the molecular states will occur, even under zero-field conditions. Under high field conditions, the charge transfer processes are emphasized. The details of these processes, which are inherently time-dependent, provide a microscopic alternative to Schottky and Fowler-Nordheim mechanisms. The possibility of "hot" electrons being generated via the localized tunnelling processes

and of cascades of energy being released as stored charge is induced to move in the solid under a high field is considered. The latter can lead to breakdown which, by reason of the localized nature of the tunnelling process, will be filamentary in nature. The importance of considering the electrochemistry of likely breakdown processes on a molecular scale is stressed.

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