HIGH FREQUENCY CHARACTERISTIC STUDIES OF THE n-CHANNEL ENHANCEMENT MODE POWER MOSFET DEVICE

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Abstract

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High Frequency Characteristic Studies of the n-Channel Enhancement Mode Power MOSFET Device

The n-channel enhancement mode power MOSFET device which is known to have the highest switching speed among the controllable switches group is the device studied in this research work. This commercially packaged device manufactured by Harris Semiconductor has a combination of MOSFET and JFET structures superimposed. It has a p-type MOS gate and a reversed biased field induced p/n junction laterally at the surface and a vertical JFET structure.

A Keithley 590 C-V Analyzer was used to characterize this device. High frequency (1MHz) capacitance-voltage (C-V) and conductance-voltage (G-V) characteristic were measured across the gate-source, gate-drain and source-drain terminals of the device. These terminals were biased at voltages ranging from –7V to 7V and the remaining terminal was grounded and was used as a reference voltage. C-V and G-V curves obtained were analyzed and related to the structure of the device. Since the switching properties are dependent on the electrical properties across the gate-source structure, detailed measurements were concentrated across this structure. The C-V and G-V measurements were done at different temperatures ranging from room temperature to 175°C. The device was annealed at different temperatures ranging from 100°C to 400°C. Since, significant effects were observed on the C-V and G-V curves of the device

annealed at 400°C, similar measurements done on the device prior to annealing were repeated on the device annealed at 400°C.

The C-V characteristic produced a p-type MOS characteristic when negatively biased and an n-type MOS characteristic when positively biased. The switching properties of a "normally OFF" device was observed from the G-V characteristic curve. Increasing the measurement temperature resulted in the shift of the C-V and G-V curves towards zero gate voltage in both the positive and negative biased regions. These shifts produced significant effects on the peak conductance voltage, capacitance and conductance values at zero gate voltage and peak conductance value.

Annealing at 400°C showed significant effects on the "turn-off" and "turn-on" conductance value however showed almost insignificant effect on the "turn-on" voltage. These results were analyzed to provide physical explanation to the operation of the device, the tolerance of this device to extreme temperatures and device performance at temperatures above room temperatures.

Abstrak

Kajian Sifat Frekuensi Tinggi
Untuk Peranti Kuasa MOSFET Mod Tertingkat Saluran-n

Peranti kuasa MOSFET mod tertingkat saluran-n (n-channel enhancement mode power MOSFET device) yang memang diketahui mempunyai kelajuan suis paling tinggi diantara kumpulan suis yang boleh dikawal adalah peranti yang dikaji di dalam kerja penyelidikan ini. Peranti terbungkus secara komersial buatan Harris Semikonductor ini adalah gabungan struktur MOSFET dan JFET yang disuperimposkan. Secara merentas di permukaannya ia mempunyai struktur get MOS jenis-p dan simpang p/n medan teraruh pincang songsang dan secara menegak struktur JFET.

Suatu alat penganalisis Keithley 590 C-V digunakan untuk menciri peranti ini. Ciri Kapasitan-Voltan (C-V) dan Konduktan-Voltan (G-V) frekuensi tinggi diukur merintangi terminal get-sumber, get-salir dan sumber-salir peranti ini. Terminal-terminal ini dipincangkan pada voltan diantara –7V hingga 7V dan terminal yang tertinggal dibumikan dan digunakan sebagai voltan rujukan. Lengkung C-V dan G-V yang didapati dianalisakan dan dihubungkaitkan dengan struktur peranti. Oleh kerana sifat-sifat suis bergantung dengan sifat-sifat elektrik yang merintangi struktur get-sumber, ukuran-ukuran terperinci ditumpukan merintangi struktur ini. Ukuran-ukuran C-V dan G-V dilakukan di suhu-suhu berbeza diantara suhu bilik dan 175°C. Peranti ini juga desepuhlindapkan di suhu-suhu berbeza diantara 100°C dan 400°C. Oleh kerana kesan ketara diperhatikan pada lengkung C-V dan G-V untuk peranti yang disepuhlindapkan pada 400°C, ukuran yang dijalankan ke atas peranti sebelum disepuhlindapkan diulangi ke atas peranti yang disepuhlindapkan pada suhu 400°C.

Ciri C-V menghasilkan ciri MOS jenis-p apabila dipincangkan negatif dan ciri MOS jenis-n apabila dipincangkan positif. Sifat-sifat suis peranti "kebiasaan TERTUTUP" diperhatikan daripada lengkung cirian G-V. Peningkatan suhu ukuran menghasilkan anjakan lengkungan C-V dan G-V ke arah voltan get sifar. Anjakan-anjakan ini menghasilkan kesan ketara kepada voltan konduktan puncak, kapasitan dan nilai-nilai konduktan pada voltan get sifar dan nilai konduktan puncak. Sepuhlindap di suhu 400°C menunjukkan kesan-kesan ketara pada nilai-nilai konduktan "suis tutup" dan "suis buka" namun tiada kesan ketara ke atas voltan "suis buka" diperhatikan. Keputusan-keputusan ini dianalisakan untuk menerangkan secara fizikal operasian peranti, toleransi peranti kepada suhu ekstrema dan prestasi peranti disuhu-suhu lebih daripada suhu bilik.

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