EFFECTS OF TOTAL DOSE IRRADIATION ON SEMICONDUCTOR DEVICES

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END OF E-SCIENCE FUND PROJECT REPORT
PROJECT NO: SCF0046-STS-2007

SEKOLAH SAINS DAN TEKNOLOGI
UNIVERSITI MALAYSIA SABAH
2009

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ABSTRACT

The amount of ionizing radiation that semiconductor devices encounter during their lifecycle degrades both of their functional and electrical parameter performances. The different radiation environments either in space, high energy physics experiments, nuclear environment or fabrication process as well as for standard terrestrial operation possess an impact on the devices. This makes that the devices based on III-V semiconductors are probable to be critical components of future electronic systems as the demand for greater robustness and susceptibility to well function in rigorous radiation environments continue to increase. Expanding electronic systems into such radiation environments requires a full understanding of the effects that ionizing radiation will have on the semiconductor properties. In this research, analytical studies of the effects of ionizing radiation introduced in commercial-off-the shelf (COTS) NPN bipolar junction transistors (BJTs) and optoelectronic devices by ionizing radiation, Cobalt-60 (^{60}Co) gamma (γ) rays and x-rays had been performed. The Total Ionizing Dose (TID) effects are cumulative and gradually take place throughout the lifecycle of the devices exposed to radiation. Ionizing radiation causes ionization by possesses enough energy to break the atomic bonds which in turn create electrons and holes pairs in the devices. This phenomenon leads to ionizing damage as a result of trapping of excess charges on or near the surfaces of their insulating layers and interfaces. At the end of this testing, the devices under test (DUT) were found to undergo performance and also temporarily degradation in both of their functional and electrical parameters due to the accumulated total dose effects. These damaging effects were depending on their driving current and also the Total TID absorbed.

Keywords- bipolar junction transistor (BJT); optoelectronic devices; gamma (γ) rays and x-rays driving current; Total Ionizing Dose (TID)

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ABSTRAK

Jumlah sinaran pengionan yang alat-alat semikonduktor bertemu dalam kitaran hidup mereka mendegradasi kedua-dua parameter fungsian dan elektrik persembahan. Kepelbagaian sinaran persekitaran sama ada di angkasa, uji kaji fizik tenaga tinggi, persekitaran nuklear atau proses rekaan dan juga bagi operasi daratan standard memberi kesan kepada alat-alat itu. Ini menyebabkan alat-alat yang dibina berdasarkan semikonduktor kumpulan ke-III hingga ke-V berkemungkinan menjadi komponen-komponen penting bagi sistem-sistem elektronik masa depan sebagai permintaan untuk komponen berintangan tinggi yang dapat berfungsi dalam keadaan sinaran yang lebih lasak. Penelapan sistem-sistem elektronik kepada persekitaran sinaran sedemikian memerlukan pemahaman yang mendalam terhadap kesan-kesan sinaran pengionan pada semikonduktor. Dalam penyelidikan ini, kajian analisis kesan-kesan sinaran pengionan diperkenalkan dalam NPN transistor persimpangan dwikutub komesil dan alat-alat optoelektronik oleh sinaran pengionan iaitu sinaran gama (γ) ^{60}Co dan sinaran-x telah dipersembahkan. Kesan jumlah dos pengionan adalah kumulatif dan beransur-ansur berlaku sepanjang kitaran hidup alat-alat yang terdedah kepada radiasi. Sinaran pengionan menyebabkan pengionan dengan mengenakan tenaga yang mencukupi bagi memecahbelahkan hubungan atom dan seterusnya mewujudkan pasangan elektron dan lubang dalam alat-alat itu. Fenomena ini menyebabkan kerosakan ekoran daripada pemerangkapan caj-caj lebihan pada atau dekat permukaan-permukaan lapisan-lapisan dan antara muka penebat. Di akhir ujian ini, alat-alat semikonduktor yang diuji didapati mengalami kesan degradasi samada secara kekal ataupun sementara dalam kedua-dua parameter fungsian dan elektrik akibat daripada jumlah dos. Kesan-kesan degradasi ini bergantung pada arus panduan dan juga jumlah dos terserap.

Kata kunci- transistor persimpangan dwikutub; alat-alat optoelektronik; sinaran gama (γ); sinaran-x; arus panduan; jumlah dos terserap

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