Radiation effects on the electrical performance of GaAs/GaAlAs HEMT´s.

Ulf Dahlgren, Staffan Rudner, National Defence Research Establishment, P.O. Box 1165, S-58111 Linköping, SWEDEN. Tel. +4613118000, Fax. +4613131665
Magnus Willander, Dept of Physics and Measurement Technology, Linköping University, S-58183 Linköping SWEDEN

HEMT´s (High Electron Mobility Transistors) are, and will be a common choice as preamplifiers in satellite communication both on and off ground. An other application is fast digital circuits. For space applications the radiation hardness is important due to the cosmic radiation. An upper total dose limit of 10 krads(Si)/year is often mentioned.
In this work we have studied the effect of gamma radiation on DC, microwave and noise performance. The transistors used for this investigation are comersially available GaAs/GaAlAS HEMT`s from GOULD and NEC. The devices were exposed to a total dose of 100 and 200 krads(Si) with a dose rate of approximately 2 krad(Si) per hour.
From the DC characterisation it is seen a 7 % per 100 krad increase in the drain current when the gate was biased for minimum noise. 0ther effects of radiation were a decrease in the pinch-off voltage and a flattening of the Gm=f(Vg) curve with a lower peak transconductance. At the gate voltage for minimum noise, the radiation induced shift in the transconductance has its minimum. The observed shift in the pinch-off voltage could cause problem in digital cicuits based on for example E-D-logic.
For the microwave analysis the HEMT´s were only biased at the point for minimum noise since this propably will be most likely bias point in microwave reciever applications. The only significant change in the scattering parameters with irradiation was a slight increase in the magnitude of S_{21} and a decrease in the magnitude of S_{22}. A lumped element equivalent circuit was fitted to the S-parameters. Since the change in the S-parameters was rather small the accuracy in the parameter extraction was not very high. The only parameter change outside the uncerainity limit was a decrese in the sum of source and gate resistance and the gate charging resistance. Minimum noise and 50 Ω noise were also measured but all changes were within the measurement uncerainity.
One possible explanation for the reported effects is an introduction of radiation-induced defects which acts like donors.
In conclusion we could say that HEMT´s are more sensitive to irradiation than FET´s. We can see significant changes in the DC performance while the microwave performance remains rather intact, at the chosen bias point.