Name of research institute or organization:

ABB Switzerland Ltd, Semiconductors

Title of project:

Cosmic ray induced failures in biased high power semiconductor devices

Project leader and team

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Project description:

Biased high power semiconductor devices like diodes, thyristors or IGBTs might fail suddenly without any previous device wear-out or electrical overload condition. This phenomenon is explained by cosmic rays where one particle triggers inside the biased silicon bulk a localized breakdown event, finally destroying the devices [1-4]. Accelerated tests reducing costs and time are feasible at locations with enhanced cosmic ray fluxes (e.g. at Jungfraujoch) or with particle beams.

The test setup was located on a platform (area 0.7 m^2) just below a wooden roof of the Sphinx observatory. About 10 to 500 devices of one or two different types or designs were tested in parallel. Failed devices due to cosmic rays were identified by observing a constant leakage current until the occurrence of the failure and by characteristic defects like small spots somewhere on the silicon chip [5,6]. The measured failure rates and the characteristic defects of the chips depended on the device types and the applied biases but were in first order independent on the incident particle type (neutron or proton beams and cosmics).

The sharp drop of the failure rates below a characteristic bias U_c was observed for all device types but so far only with proton and neutron beams (Fig. 1). The poor statistics with cosmic tests did not allow to reproduce this drop-off. The predictions for most of the device types were in fair agreement with the test results except for the sharp drop of the failure rates [4].

The biases for typical device applications are normally below U_c. Typical applications of high power semiconductors demand failure rates of power devices due to cosmics lower than one failure every 10^9 hour and every 1 cm^2 device area. Thus it is of vital interest to know if the failure rates due to cosmics exhibit a similar drop-off behaviour similar to those due to neutron or proton beams.

In 2002 a test sequence with an increased number of devices was started to clarify the possible drop of the failure rates due to cosmics below U_c. This experiment was continued in 2003.

Glossary

IGBT: Insulated Gate Bipolar Transistor; voltage controlled power transistor.

References

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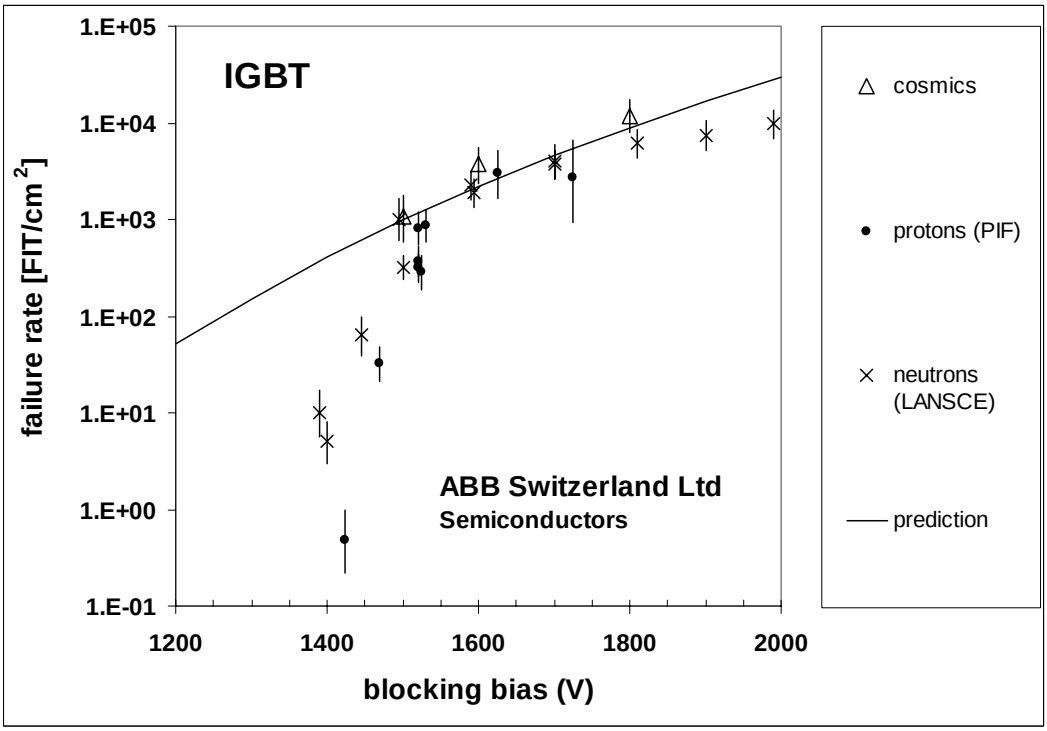

Fig. 1: Failure rates of a certain IGBT device due to cosmics, protons (PSI-PIF, 300 MeV) and neutrons (LANSCE, energy spectrum proportional to 1/E and with E < 800 MeV). Here the application bias was well below the characteristic bias U_c = 1500 V. All failure rates were normalized to New York City and to a temperature of 25 °C. One FIT/cm^2 corresponded to one failed chip every 10^9 chip·hour normalized to one cm^2 silicon area.

Key words:

cosmics, power semiconductor devices, failures

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