IAF MATERIALS AND STRUCTURES SYMPOSIUM (C2)
Space Environmental Effects and Spacecraft Protection (6)

Author: Dr. Jochen Kuhnhenn
Fraunhofer Alliance Space, Germany, jochen.kuhnhenn@int.fraunhofer.de

Dr. Stefan Metzger
Fraunhofer Alliance Space, Germany, stefan.metzger@int.fraunhofer.de
Dr. Stefan Höffgen
Fraunhofer Alliance Space, Germany, Stefan.Hoeffgen@int.fraunhofer.de
Dr. Michael Steffens
Fraunhofer Alliance Space, Germany, michael.steffens@int.fraunhofer.de

FUTURE RADIATION TESTING: ADAPT OR FAIL

Abstract

Radiation testing is a major challenge for nearly all space applications. Methods were developed and standards defined, leading to an accepted way to qualify components for a reliable operation under space radiation conditions.

However, many new aspects with respect to space radiation appeared that can potentially overturn decades of "best practice" and existing standard procedures. We may need to define radically new approaches, because in several cases traditional testing methods might or will fail.

Three major radiation effect types exist: total ionizing dose damage (TID), displacement or non-ionizing dose damage (DD), and effects induced by single particles hitting a sensitive volume (SEE).

TID testing used to be focused on the qualification of HighRel components with strict lot and process control and full traceability. Established methods to yield test results with sufficient statistical uncertainty were applied. Recently the demand for using COTS parts in space has increased strongly. But since the manufacturers' information about the components is not comparable to what is given for HighRel parts the whole concept of lot-acceptance test is failing.

DD testing is based on the assumption, that the energy-dependent lattice defects caused by a continuous particle spectrum in space can be simulated with a certain fluence of mono-energetic particles. This is called the NIEL hypothesis. This has been successfully established for Si-based devices. Two preconditions are needed to extent this method to other materials: The principle must still be valid and the necessary input data has to be available. Both conditions are currently not met and most DD testing beyond Si-based devices might not be reliable today.

The situation is even worse for SEE testing. To completely characterize a device response to, e.g., heavy ions, in principle one has to operate the device in all possible modes and states, collect all relevant data in real time, and hit all sensitive areas with sufficient statistics. With modern highly integrated devices this is not possible with reasonable means. Moreover, even if the reduction of the testing modes, data collection and limitation to parts of the device is possible, the requirement to penetrate all sensitive volumes demands the opening of the package. While this is at least challenging for most modern devices, multi-layer structures remain inaccessible with conventional test facilities.

The presentation will give examples for the above mentioned topics and discuss possible ways to resolve these challenges.