PRESS RELEASE

INT's First Test Series using Picosecond Lasers for Mapping of Single Event Effects (SEEs)

Euskirchen - at the Fraunhofer Institute for Technological Trend Analysis INT in Euskirchen, scientists from the Business Unit Nuclear Effects in Electronics and Optics (NEO) have launched a series of tests with a newly installed picosecond laser. The aim is to locate places on electronic devices that are susceptible to Single Event Effects (SEEs). SEEs occur when particles of cosmic, ionizing radiation such as neutrons or protons impact on electronic components. This can lead to temporary malfunctions or to permanent damage that makes an electronic device completely inoperable.

In the last 20 years, the relevance of SEEs has grown considerably. Dr. Stefan Metzger, one of the project leaders and head of the Nuclear and Electromagnetic Effects Department (NE) at INT, explains: "There is a tendency to miniaturize components and to increase packing density. Today, when an ionizing particle impacts, the number of affected components is higher than it was a few years ago, so the damage caused is more important for a device's performance. This is particularly a problem with new trends such as autonomous driving and e-mobility, which use highly-integrated control and power electronics." Since SEEs play an increasingly important role in such future technologies, research work on them is also gaining in importance. The laser at INT provides the opportunity to identify points where components are sensitive to SEEs, offering a basis for SEE countermeasures.

A neodymium-doped yttrium-vanadate laser with a wavelength of 1064 nanometers is used to stimulate the SEEs. Due to the low wavelength, the laser can be focused on very small areas. Since it is also a picosecond laser, it is capable of producing short pulses with a duration of nine picoseconds - one picosecond is just one trillionth of a second. Using the laser, it is possible to imitate the impact of an ionizing particle on an electronic component, and the effects of such a simulated SEE can then be analyzed.

A Precision Laser that Cuts Costs

In contrast with comparable tests using accelerators, work with the laser is easier. This is because no complex radiation protection is necessary, and in total, laser technology is much cheaper and more economical to use. Alternative SEE tests, such as using accelerators to bombard components with heavy ions, are not nearly as accurate. It is not possible to determine where a heavy ion impacts on the component and it is not possible to fix the exact location of the effect. With the laser, however, the position of the SEE can be precisely determined on a micrometer scale. This makes it possible to determine locally the probability of the various types of SEE impacting on a component. Experiments with

Editorial notes
Thomas Loosen | Fraunhofer INT | Communications | Phone +49 2251 18-308 | thomas.loosen@int.fraunhofer.de |

the laser system have also shown up SEE patterns that have not been observed in tests using heavy ions. Dr. Metzger: "The test series with the laser offers completely new possibilities for error analysis."

The prerequisite is that the component has to be opened, since otherwise the laser light does not penetrate the sheath. This step is also performed at INT by using a special device for etching component housing. A laser beam of less than five micrometers in diameter is focused on the target component by means of a microscope lens. Simultaneously, an acousto-optic modulator (AOM) lets through just one pulse to the component, so simulating a single ionizing particle strike. The component is then scanned in steps of down to 100 nanometers and exposed with varying laser energy levels, and the effects are analyzed. This makes it possible to create a map of the component that shows which regions are susceptible to SEEs.

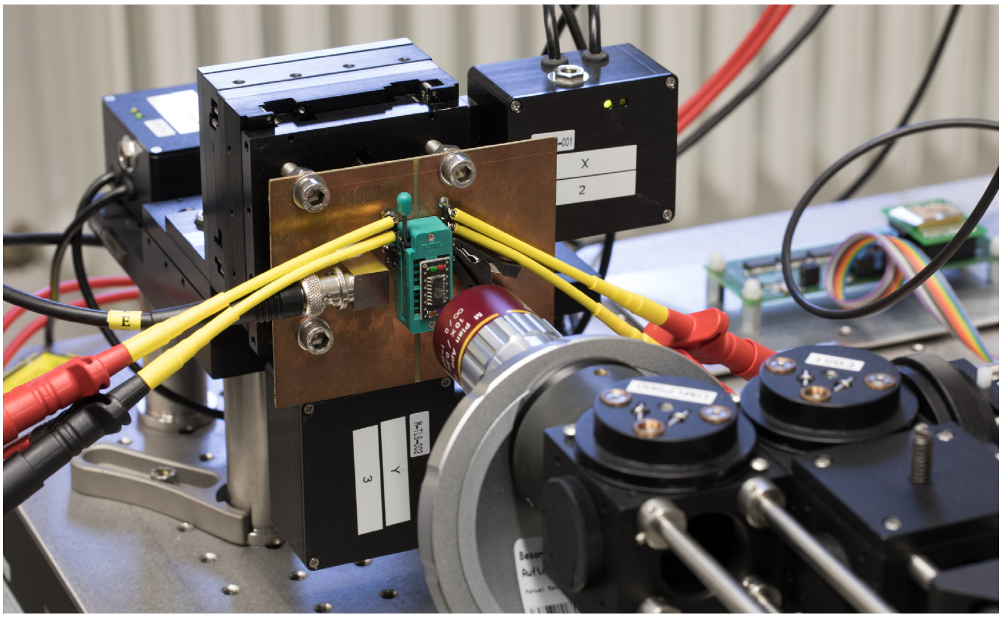
Bombardment from Space

What triggers the effects studied is a phenomenon from astrophysics: the Earth is continuously under attack from cosmic radiation. It comes from the depths of space and consists largely of protons, helium nuclei and some heavier nuclei. One particle of this cosmic radiation can cause a Single Event Effect. Different types of SEE can occur. For example, a Single Event Functional Interrupt (SEFI) causes a temporary loss of normal functionality, whereas a Single Event Burnout (SEB) creates a permanent short circuit.

The radiation dose in space is greater, than here on earth, so especially the aerospace industry is looking closely at radiation effects on electronic components such as SEEs. Systems and components onboard of satellites or even aircrafts are particularly susceptible to SEEs. The intensity of radiation from space decreases as it gets closer to the Earth, since it is absorbed by the atmosphere and the magnetic field. However, individual particles can still penetrate through the atmosphere to the Earth's surface and cause SEEs. For example an election irregularity in the Belgian constituency of Schaerbeek – 4096 votes too many were registered, exactly 2^{12} – suggests that the fault might be attributed to a bit error caused by an SEE. Such effects can cause even more dramatic malfunctions and failures in cardiac pacemakers and other health-related devices.

The Fraunhofer INT offers science-based analysis and assessment capabilities across the entire technical development spectrum. In-house expert analyses and prognoses in select fields of technology as well as theoretical and experimental work in the fields of electromagnetic and nuclear effects will flesh out this summary.

Editorial notes
Thomas Loosen | Fraunhofer INT | Communications | Phone +49 2251 18-308 | thomas.loosen@int.fraunhofer.de |



Experimental setup with electronic device and microscope lens.

www.int.fraunhofer.de

Editorial notes
Thomas Loosen | Fraunhofer INT | Communications | Phone +49 2251 18-308 | thomas.loosen@int.fraunhofer.de |