Microelectronics education for aerospace industry.

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Abstract

The special microelectronics educational program for aerospace industry has been developed at MIEM. The primary purpose of this program is to prepare the designers, developers and producers, aimed at achieving long term reliability of aerospace electronic equipment. The educational process is carried out in collaboration with the aerospace industry enterprises.

1. Introduction

Moscow State Institute of Electronics and Mathematics (technical university) (MIEM) is one of the leading russian universities in preparing engineers and researchers for electronics and microelectronics.

Microelectronic equipment for aerospace applications in comparison with the equipment for conventional environment has to be designed and tested taking into account the additional key factors, influencing on reliability:

1) mechanical stress caused by vibration, shocks and acoustic noise;
2) thermal problems caused by high power dissipation;
3) space ionizing radiation effects.

2. Special aerospace microelectronics educational program

The special aerospace microelectronics educational program for students and industry engineers has been developed at MIEM.

It is supported by the Ministry of Education and Science of the Russian Federation and Russian Federal Space Agency.

This program has more than twenty years history and it is regularly corrected and gets additional elements and materials according to aerospace industry needs.

Academic educational program for students.

The standard MIEM microelectronic curricula include the following core coursers:

- microelectronics materials, technology, equipment,
- physics, devices,
- digital and analog ICs,
- memory, microprocessors,
- FPGA/PLD,
- PCBs, units design,
- CAD systems ,
- circuit testing and measuring,
- microelectronics reliability.

In addition to standard microelectronics curricula MIEM has developed special extended courses for preparing engineers for aerospace industry:

The aerospace microelectronics curricula include the following special courses:

- space radiation environment for electronics;
- radiation effects on microelectronic materials, devices, circuits, PCBs, units;
- thermal analysis and heat transfer for electronics;
- design of radiation-hardened ICs for space;
- heat engineering, heat sink selection, cooling systems;
- radiation measuring and testing of semiconductor devices and ICs;
- thermal measuring, control and monitoring of electronic devices, ICs, PCBs, units;
- mechanical stress on electronic equipment;
- semiconductor device reliability;
- electronic system reliability;
- application of CAD systems for radiation, thermal and mechanical hardness evaluation.

The educational process is carried out in collaboration with aerospace industry enterprises:

- S.P. Korolev Rocket and Space Corporation “Energia” ;
- AVIONIKA Moscow Research-and-Production Complex (JSC);
- Federal State Unitary Enterprise “Scientific and Production Association “ Pulsar”;
- Federal State Unitary Enterprise “Scientific and Production Association “Orion”.

The leading specialists from these enterprises give lectures and provide special labs for students.

The students take part at real industry projects, defense their theses and take an engineer’s or master’s degree. The ongoing relationship with aerospace industry provides relevance and real-world orientation of our teaching and research.

The desirable level of training for ordinary, advanced and post-graduate students is foreseen.

Reeducation program for industry engineers.

The following main directions of reeducation and improvement in qualification are critical for practical aerospace industry engineers:

- new generation of microelectronics components based on deep-submicron technologies;
- System-on-Chip design;
- radiation and thermal effects on deep-submicron devices and VLSIs;
- application of CAD systems for the design of radiation, thermal, mechanical -hardened VLSI for space;
- mixed A/D, electrical/thermal/mechanical design for space microelectronic systems.

The listeners can select the desirable level of training course: introductory, standard, advanced. The specially ordered professional courses for working engineers and/or designers are foreseen.

3. Physics of failure analysis – important part of educational program

Aerospace, naval and military companies often must design systems for use in severe life environment.

Preventing electronic component level damage under radiation/thermal/mechanical influence is key to developing more reliable products – while reducing costs.

Physics of Failure (PoF) approach based on computer modeling is used to provide full understanding of how an electronic component responds to influence.

That's why computer modeling of thermal/radiation/mechanical effects in aerospace microelectronic equipment is an important part of our curricula.

Thermal analysis.

Level 1 : discrete devices and IC elements.

For power devices (diodes, BJTs, MOSFETs, MESFETs, IGBTs) and low power submicron VLSI elements (CMOS, CMOS SOI, BiCMOS, HBT SiGe) the self-heating effect is important.

Software tools for simultaneous numerical computations of coupled electrical and heat conduction phenomena are used:

DESSIS (ISE TCAD) - for 2D/3D simulation of temperature distribution in physical structures of electronic components;

SELFHEATING (MIEM) – for electronic components layout optimization from thermal standpoint.

For circuit simulation with SPICE the electro-thermal models of components are used.

Level 2: Monolythic and hybrid ICs.

2D/3D thermal numerical simulators OVERHEAT-IC (MIEM) and OVERHEAT-HIC (MIEM) are used for temperature profiles analysis, "hot-spot" detection and layout thermal optimization.

Level 3: MCMs, PCBs, units.

For MCMs and PCBs 2D thermal analysis software tools AUTOTHERM and BETASOFT (Mentor Graphics) are used.

For PCBs and units 2D/3D thermal analysis with natural and forced convection software tools FLOTHERM and ASONIKA-T (MIEM) are used.

Radiation effects analysis.

The commercial software tools with specially developed models are used for analysis of the effects in electronic equipment caused by galactic cosmic rays, solar radiation, Earth radiation belts particles.

Level 1: Semiconductor device and IC elements.

For 2D/3D simulation of semiconductor device structures taking into account radiation effects the software tool DESSIS (ISE TCAD) with built-in special radiation models is used [1,2].

Level 2: ICs and VLSI fragments.

For ICs and VLSI fragments simulation with SPICE the special radiation-dependent models of BJTs, CMOS, CMOS SOI/SOS, BiCMOS, GaAs MESFETs are used [2,3].

Mechanical analysis.

Level 1: semiconductor devices and IC chips in packages.

The deformation and stress tensors for 2D/3D constructions are simulated with ANSYS and COSMOS tools.

Level 2: PCBs and units.

Mechanical stress and vibration–induced failure analysis is performed with ANSYS and ASONIKA-K (MIEM) simulators.

The special training courses are organized to get students and industry engineers an experience in using the above-mentioned software tools.

4. EDUCATION-RESEARCH CENTERS –THE IMPORTANT PART OF MIEM EDUCATIONAL STRUCTURE

Five Education-Research Centers of MIEM moreover than corresponding academical departments of the University take part in education process to intensify the training courses and labs.

Motorola and Renesas Centers provide training for students and industry engineers to the principles of operation and characteristics of modern electronic components, microcontrollers, microprocessors, telecommunication and network equipment.

ZyXEL Center provides training to get and/or improve the experience in the field of the network technologies, information security and network equipment.

Xilinx Center provides education for MIEM students and reeducation for industry engineers in the field of modern digital FPGA systems design with VHDL. The Center has special development boards (with the last versions of FPGA) for projects implementing and debugging.

Mentor Graphics training Center is equipped with the modern versions of MG software running on PC computers. The goal of the Center is to teach students the basic techniques for analysis and design of perspective analog and digital systems based on IC chips and PCBs.

In Synopsys Center students get experience in technology/device simulation with TCAD software.

In cooperation with the leading russian semiconductor companies the students participate in SOI/SOS CMOS, SiGe HBT, BiCMOS devices design projects.

5. CONCLUSIONS

Our experience shows that the MIEM educational program for aerospace industry engineers is a good example of university and microelectronics industry collaboration.

Different aspects of the MIEM educational program were presented and discussed at international conferences and exhibitions [3-5].

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