Third Stage of Hybrid Integrated Circuits – the Education Process in the Microelectronics Technology and Packaging

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Abstract: Article deals with the new approach to the education process focused on microelectronics technology and packaging that utilizes technology of Hybrid Integrated Circuits (HIC). It describes available methodology of teaching in terms of sequence of operations and possibilities for their adaptation to demonstrate basic principles from assembly and packaging of electronic circuits and systems in the experimental education.

1. INTRODUCTION

This paper describes the new approach to electronic engineering education utilizing hybrid IC’s technology for demonstration of fundamental principles and relations that are applied in common electronic engineering praxis. There is good chance for universities and high schools to educate the basic hardware in electronics by developing of non-expensive lab for efficient experimental curriculum. Object of this paper is to describe the basic steps for involving this activity in educational process. HIC’s technology offers a good chance to demonstrate many technical effects running in electronic hardware.

2. STRUCTURE OF THE EDUCATION PROCESS

As the Figure 1 shows the structure of education is given by the sequence of technological processes. Information about all these parts students can be obtained from the lectures. The laboratory exercises should include a complete technological process, which basically describes the fundamental rules and principles used in technological processes in general.

![Fig. 1 Modern Microelectronics Technology Curriculum](image1)

![Fig. 2 Syllabus of laboratory exercise](image2)
From the mosaic in Figure 1 can be selected parts of the theoretical training. Figure 2 shows the syllabus of laboratory exercises, which is based on a Hybrid Integrated Circuits Technology.

2.1 Education process - DESIGN

In this section, students are introduced with the circuit solution of a particular electric scheme. At first they must decide the dimension of the ceramic substrate. It depends on the types of component, of course thick film layers and SMDs. Next criterion for component selection is material of dielectric for capacitor, resistor package dimension, power dissipation, etc. These parameters of every components, depends on layout of the circuits layout.

Output of the hybrid integrated circuit design is creating a mask for making the screens.

2.2 Education process – SCREEN PRINTING

Fully practical part start deal with the creation masks on the screen. Next, if from all masks are created appropriate screens, following the screen printing process. This process is a cycle of printing, drying and burning in different configurations depending on the type and number of printed motives. Parameter of the process depends on the type of thick film pastes too, in particular, temperature and timing of the burning process. These steps are very important for laboratory education, because the students learn the sequence of operations and the occasion for timing. During this second part is necessary to take into account the sensitivity of the printed motives in the context of the viscosity of thick film pastes.

Output from the second part is ceramic substrate with the conductive motive and the resistor layers. This result is continuously visually evaluated.

2.3 Education process – ASSEMBLY PROCESS

Assembly process starts with stencil printing of solder paste and place the SMDs and following the burning of solder paste. For the completion of the assembling students have to prepare the adhesive for the chip attach. That placed chip is prepared for fixing the position by the cure of an adhesive. This is the third and final temperature operation before chip and substrate interconnection. Contacting the chip is realized by the thermosonic wire bonding machine. This process is made by the semi-automatic machine and students can make a wire-pull testing of realized interconnections.

Output of this assembly and interconnect sequence is prepared electrical circuit for functional testing.

2.4 Education process – TEST, PACKAGING

Last laboratory exercise is focus on the verification of student products in the view of electrical parameters. After successful testing is substrate ready to mounting the pins and packaging.

Statistic evaluation of this operations use the measured data for make a technical report the term of project. This is the aim of the education process and it must be evaluate as a whole.

3. TECHNOLOGICALLY SIGNIFICANT PARTS

Individual parts of the educational process give to student information from important areas of technology and allow student to practical involvement.

3.1 Design

First information, which student get about project, is the own layout of the circuit. By this way they get to know the circuits function. Design is made by the computer software Eagle. In that software students learn the design rules.

![Fig. 3 Samples of designed circuits](image-url)
As is shown in Figure 3 the design has some rules for dimension of the ceramic substrate and orientation points.

### 3.2 Screen printing and firing processes

The rules, dimensions and the layout is definitive output from first part and it is the input parameter for manufacturing of real structure. In this case follow the screen printing process with selected type of thick film paste. Parameters like temperature for store the pastes, heating by ambient to operating temperature and viscous behavior of thixotropic materials are in this phase very important. In the Figure 4 you can see the detail of masked screen with 300 mesh.

The temperature profile of burning process for thick film paste, which achieves the values 850°C (Figure 6), should be combine in education process with the solder reflow process with peak temperature under 260°C.

![Fig. 4 Detail of masked screen](image)

**Fig. 4 Detail of masked screen**

Paste requirement for temperature, purity and the homogenization is able to sensitively differentiated students results as well as the need to readjust other parameters. Screen printing follows the operation called *leveling*, drying in the oven at the low temperature and then the final burning. Detail structure of thick film layer shows the Figure 5.

![Fig. 5 Detail of Thick film conductive structure](image)

**Fig. 5 Detail of Thick film conductive structure**

This two temperature profile is very similar by the shape, but radically different in the terms of time and the temperature.

The sintered thick film structure is after burning ready for next stage that containing the assembly process.

### 3.3 Assembly process

Optical inspection is the first such operation for each process during experimental work. The visualization, which is done by some operations through camera, in the other by microscope, easily shows the realized structures, by laser cut layers and other details of assembly process including wirebonding.

Stencil printing is the starting operation for deposition of the solder paste or glue. There are two possibilities for mounting devices; mounting of SMD components completely or mounting of semiconductor dies. For this last is the significant temperature process curing of the adhesive under the chip, which is placed into the circuit. Semiconductor chip is connected in circuits by thermosonic principle that combines two basic techniques, the ultrasonic and the thermo-compression. Reliability of interconnection asks the necessity of the purity. Not only the chip purity but the clean room too. Fineness of the bonding wire, 25µm diameter, determines using this interconnected system in conjunction with mechanical protection, the package. The
encapsulation and packaging of the chip is realized as a Glob Top package and by this operation is made the output from this assembling part.

In the case of complete SMD performance is the substrate assembled with SMD components by using semi-automatic manipulator and after that follows the reflow soldering process. Here can be indicated a possible design errors of the pads design.

3.4 Testing and final packaging of the realized circuit

Final part of the education process is mounting of pins to substrate using soldering process. After this operation follows testing of the completed circuit, where defined output parameters are checked.

The type of final packaging of the completed circuit depends on its function. We used often the fluidization method and our plans are to package by the transparent epoxy for circuits with some optical preferences or lighting function.

After this technological- sequence of the operations student have to produce the technical report of whole project. All parts have to be theoretically briefly described but the main parts, the measured values, setups of the equipments or evaluating of processes must be described in detail and of course statistically evaluated. Here is used for example Gauss or factorial analyze. It means that education process requests are focused on technological knowledge, where the theory is very closed to its practical use and application. Technical report is indeed one of the less popular things for students, but just that it is practically the last and necessary part in the production, has to be write in students’ memory.

![Image](image.png)

**Fig. 8 Shear test of SMD components**

Improvement each part of this learning process is due to targeted modification of the laboratory exercises. Especially by the introduction of the visualization of processes, where students can directly observe the process dedicated to screen printing, assembly, wire bonding, etc. [4]

4 SIMULATION PROGRAM

A part of the education process makes also the simulation in ANSYS program. That enables to perform thermal, mechanical and electric field simulation. There was developed for education of students the special program for stress lay on packaging issues, especially on packages with ball leads including BGA. These types of packages are dealing with many undesirable effects, from problems with thermo mechanical stress, till creation of voids and cracks in connections. Generally we can model different conditions using PC systems, but for accuracy of simulation is the most important to specify material properties and initial conditions. Results are presented by chart, animation or by number in monitored point or area.

5 THE IMPORTANCE OF FOCUSING ON HYBRID INTEGRATED CIRCUITS AND CONCLUSION

The laboratory of Microelectronics packaging and interconnection technology is oriented on the area of sensors, specifically thermodynamics, also LTCC and the generally on interconnection technologies [5, 6, 7].
Technologically-focused devices are suitable adjusted to education process and technical support ensures a high level of study in this area. In this way is easy possible to make simulations of various processes which are comparable with processes inside of packages. These modern, as SOP, CSP, MCM etc. represents heterogeneous microelectronic systems, which is not possible to measure ordinarily and with common equipment. HIC technology is the cheap and available possibility for high schools and universities to build lab for experimental education and to improve efficiency and quality of educational process in area of microelectronic technology and packaging.

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REFERENCES


