SECTION 8.
AUTOMATION AND APPLIANCES MAKING

Nevliudov Igor
Doctor of Technical Sciences, Professor,
Head of Department of Computer-Integrated Technologies,
Automation, Robotics and Safety Engineering,
Kharkiv National University of Radio Electronics, Ukraine

Yevsieiev Vladyslav
Doctor of Technical Sciences, Professor,
Professor of Department of Computer-Integrated Technologies,
Automation, Robotics and Safety Engineering
Kharkiv National University of Radio Electronics, Ukraine

Horovyi Kyrylo
PhD student
Department of Department of Computer-Integrated Technologies,
Automation, Robotics and Safety Engineering
Kharkiv National University of Radio Electronics, Ukraine

ANALYSIS OF THE TECHNOLOGICAL PROCESS OF WEDGE BONDING USING FEK DELVOTEC 6400 IN MICROELECTRONICS

Modern development of microelectronics, power electronics, and hybrid electronic modules is characterized by the continuous reduction of component geometric dimensions, increased packaging density, and growing requirements for the reliability of interconnections. One of the key stages in the production of microelectronic devices is the process of forming electrical contacts between the semiconductor die, substrate, and package leads. To implement these tasks, wedge bonding technology using thin aluminum wire is widely applied, as it provides high positioning accuracy, stability of electrical parameters, and reliable connections during long-term operation of electronic modules. This technology is especially relevant in the production of hybrid integrated circuits, sensor systems, power modules, and specialized radio-electronic equipment [1,2].

Wedge bonding technology is based on the formation of a mechanical and thermal contact between a thin metal wire and a bonding pad by means of ultrasonic vibrations, applied force, and local friction between the surfaces. In most cases, small-diameter aluminum wire is used for interconnections due to its high electrical

conductivity, corrosion resistance, and compatibility with aluminum bonding pads of semiconductor structures. During the bonding process, the oxide film on the metal surface is destroyed, the contact surfaces are activated, and a metallic bond is formed at the molecular level. The quality of the resulting contact directly depends on the stability of the technological parameters, among which the amplitude of ultrasonic vibrations, bonding force, exposure time, and the geometric characteristics of the bonding tool are of particular importance [3,4]. An example of interconnection implementation based on the wedge bonding process is shown in Figure 1.

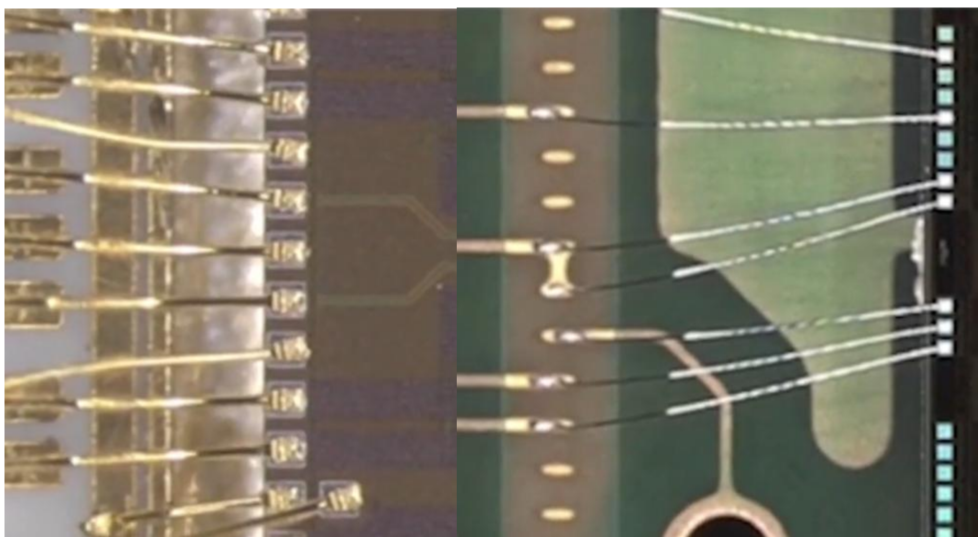

Fig. 1. **An example of interconnection implementation based on the wedge bonding process**

The technological process of wedge bonding using the FEK Delvotec 6400 consists of several sequential stages. At the first stage, the preparation of the bonding pad surfaces and the installation of the electronic module into the working area of the machine are performed. An important condition for ensuring a high-quality welded contact is the absence of mechanical damage, contamination, and excessive oxide layers on the surfaces being joined. After the module is fixed, the visual inspection system performs coordinate calibration and determines the position of the bonding pads.

At the second stage, the wedge bonding tool is moved to the first contact point. At the moment the tool touches the surface, ultrasonic vibrations and mechanical bonding force are simultaneously applied. Under the influence of mechanical vibrations, plastic deformation of the aluminum wire occurs, the oxide film is destroyed, and a metallic bond is formed. After the first connection is created, the tool moves to the second bonding pad while forming a wire loop of the specified geometry. Then, in a similar manner, the second welded connection is formed, after

which the wire is cut and the system proceeds to the next bonding cycle. [5,6]

An important aspect of studying the technological process is the analysis of the main wedge bonding defects. The most common defects include wire lift-off, insufficient bond strength, displacement of the bonding point, destruction of the bonding pad, and the formation of microcracks in the joint area. The causes of such defects may include incorrect adjustment of ultrasonic parameters, wear of the wedge bonding tool, unstable wire feeding, or contamination of the contact surfaces. To ensure the quality control of bonded connections, optical inspection methods, mechanical pull tests, and microscopic analysis of the contact zone structure are used.

Conclusion. Thus, the technology of thin aluminum wire wedge bonding is one of the key processes in the modern production of microelectronics and hybrid electronic modules. The use of the FEK Delvotec 6400 system ensures high precision in the formation of interconnections, stability of technological parameters, and automation of the manufacturing process. The analysis of the technological process features demonstrates that the quality of bonded contacts largely depends on the correct selection of ultrasonic operating modes, the stability of the positioning system, and the efficiency of process parameter control. The integration of wedge bonding technology with the concepts of digital manufacturing and digital twins opens up prospects for the creation of intelligent monitoring systems and adaptive control of manufacturing processes in microelectronics.

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