

sustainablySMART

Sustainable Smart Mobile Devices Lifecycles through Advanced Re- design, Reliability, and Re-use and Remanufacturing Technologies		
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Summary

This report D4.3 is the outcome of WP4, Task 4.1 "Remanufacturing of used semiconductor components: Desoldering" and Task 4.2: "Remanufacturing of used semiconductor components: Re-work" and it demonstrates a feasibility of reusing quality-tested components in new application.

The aim of the Deliverable 4.3 is to demonstrate the reuse of remanufactured valuable semiconductor components de-soldered from used mobile products in new devices, which was assembled in industrial environment in Semicon. Based on the conclusions from validation process of elaborated technology verified independently by ITR and Speech partners in lab and industrial environment in the Task 4.2 the components in BGA housing such as flash memory, microcontroller were selected for the new device - the alarm clock device.

Based on achieved results and labs tests, the electrical diagram and new device design was created. The new test device was designed to check assembly problems and limitations connected with the second use of remanufactured components in new applications. Based on technique (T3E3) the selected components were remanufactured from the used mobile devices and assembled in industrial environment in new test devices in Semicon. After the reliability tests the final devices were assembled in industrial environment. The lifetime tests carried out, non-destructive (X-ray) and destructive analytics (metallography) tests of the demonstrators verified independently by ITR in lab confirmed high reliability of new devices with remanufactured components.

Abbreviations

AOI	Automated Optical Inspection
BGA	Ball Grid Array
DVR	Digital Voice Recorder
ESD	Electrostatic discharge
IMC	Intermetallic compounds
MSD	Moisture sensitive device
PCB	Printed Circuit Board
PCBA	Printed Circuit Board Assembly
SMT	Surface mount technology
T3E3	Proprietary technology for remanufacturing of BGA components
THT	Through-hole technology
WP	Work Package

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1 Introduction

Based on the analysis carried out by Fraunhofer IZM in Task 3 [1] and conclusions from Task 4.1 [2] and Task 4.2 [3] the components in BGA housing such as flash memory and microcontroller were selected for a new device as a technology demonstrator. The new test device was designed as a test assembly to confirm the reliability of the reuse process. After that the final design for the application of remanufactured components was defined. Next, based on achieved results, the electrical specification, design and assembly process in industrial environment of demonstrators were implemented. The detailed specification of these demonstrator are explained in the following chapters.

2 The reliability of test assemblies

In this study, the reliability of new test device with remanufactured components was evaluated.

The new test device design

The PCB design was elaborated based on the investigations and trials carried out in Task 4.1 and Task 4.2. The two semiconductor components that are shown in Fig. 2.1 were selected for new test device: microcontroller and flash memory (marked in red). To properly check selected components the alarm clock was designed.

Selected device:	Speech digital voice recorder DPM8000	
Targeted components:	1. EFM32GG290F1024	Microcontroller
	2. S29AL016J	Flash memory



Fig. 2.1 The targeted components for new test device

The selected components are the most expensive compared to the others on the device's main board. The project partner delivered the old devices DPM 8000 and the new components.

The alarm clock project

The new test device is an alarm clock. Used memory S29AL016J allows to save 2MB audio data in wave format. Sounds/music will be loaded during production process and the user will not be able to modify them. The user can change the volume level and the time displayed.

The alarm clock has a built-in battery that will allow 40 hours of continuous operation. The device has a USB output that allows to recharge the battery. To turn off the watch, the switch on the back of the case is designed.

Based on the following assumptions the main circuit schematic diagram of the alarm clock device was created.



Fig. 2.2 Main circuit schematic diagram of new test device

Each block is a separate circuit diagram containing:

- Microcontroller EFM32GG290F1024 is the main element of the device. The microcontroller controls the measurement and displays time. It implements user commands such as the volume level change function or time modification.
- Flash memory S29AL016J is the storage place for the music files. It has 2 MB of memory.
- BCD decoder supports LCD display on which the current time is presented.
- DC/DC converter, Li-ion charger for power supply.
- Audio and digital amplifiers for audio system to play the sounds/music.

Next, the PCB layout of alarm clock device was designed.



Fig. 2.3 a) PCB layout of alarm clock, b) zoom on place for reused components, c) 3D model zoom

The new test device assembly

The two types of components (flash memory and microcontroller) de-soldered from old DVR devices were remanufactured using T3E3 technology. The main steps of the T3E3 technology were shown on the flowing charts below.





Fig. 2.5 Flow chart: remanufacturing process

The remanufactured components were assembled in industrial environment on new test devices. The automatic machines, such as a screen printing machine, Pick&Place machine, and reflow oven, were used for the manufacturing process.



Fig. 2.6 Flow chart: manufacturing process new test devices



Fig. 2.7. The new test device with remanufactured components (marked in red)

Results of reliability test in laboratory

The quality and reliability of new test devices were verified through laboratory and functional tests before and after accelerated climatic tests. All the devices that were manufactured were functional. The software was uploaded to the chips together with music files. The main function of the alarm clock has been achieved. The devices were tested in elevated temperature, so called high temperature storage, for 500h at 150deg.C. Those tests are carried out to induce stresses in the PCBA showing the weak spots of the assembly or design. After those test 3 devices were not functional. After conducting the root cause analysis it was stated that the problematic part was the switch. The thorough analysis of the data sheet showed that the switch had operating temperature far lower than the test temperature. After making this correction to the device all three were fully functional again. One of the biggest concern is the growth of the intermetallic layer (IMC). As it is known from literature, if the layer is too thick, cracks can appear at the interphase. In all tested cases no cracks have been observed and the thickness of the IMC was in the range from 3.5-5.5 μ m which is in accordance with literature data on lead-free technology for standard soldering technique. The quality was monitored also by taking the Xray images of the most crucial components that were the BGA chips. No anomalies or issues have been observed during the tests.

3 The reliability of final device

As a final device the alarm clock was used (Fig. 3.1). The two types of components (flash memory and microcontroller) de-soldered from old DVR devices were remanufactured using T3E3 technology.



Fig. 3.1. The view of the final device.

50 units of final devices were produced on Semicon's production line (industrial environment). The main steps of the industrial production were shown in Table 1.

Table 1: Main process steps of the industrial production of the alarm clock device

No	Step name	An exemplary view of process steps
00	Component after remanufacturing process ready for manufacturing	
01	Automatic solder paste printing on bare PCB	
02	SMT assembly process on Pick&Place machine	
03	Reflow soldering in the oven	
		Ketiow soldering profile

No	Step name	An exemplary view of process steps
04	AOI inspection after SMT process	
05	THT assembly	
06	Quality control	
07	Spray cleaning	

No	Step name	An exemplary view of process steps
08	Programing/Testing	
09	Final assembly	



Fig. 3.2. The pictures of the final device

The final devices (Fig. 3.2) were tested in lab by ITR, checking the functionality of the devices and the electrical and solder joints properties. All tests confirmed again high reliability of new devices with remanufactured components.

4 Conclusion

The experiments carried out proved that the use of recovered BGA chips is feasible. Semicon demonstrated the assembly of the boards with industrial equipment. The designed demonstrator devices were functional even after harsh climatic tests.

The processes demonstrate implementation of a circular economy approach, advancing the recovery of functional semiconductor packages, thus saving raw materials and replacing potentially newly manufactured semiconductor components.

5 References

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