COOP-CT-2004-005770
JOITEC

Lead-free joining for micro electronics
and micro system technology devices

Co-operative research projects
Horizontal Research activities involving SMEs (CRAFT)

Final Publishable Activity Report

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Project coordinator name: **Dr. Uwe Stute**

Project coordinator organisation name: LASER ZENTRUM HANNOVER e.V.

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Chapter 1

Final Publishable Activity Report

1. Project execution

JOITEC is an European project under the 6th R&D Framework. It has enabled laser welding technology for lead-free packaging and joining of micro components while meeting the *European Waste from Electrical & Electronic Equipment* (WEEE) - guideline and the *Reduction of Hazardous Substances* (RoHS)-guideline. For the welding process a laser with a wavelength of λ = 532 nm (green spectral range) was used. The JOITEC project finished February 2007. Promising initial results were obtained.

Due to the upcoming restrictions on lead based solders by the European Commission, new methods of joining must be developed for use in the electronics industry. To compete with the lead-free soldering processes currently used in Japan, JOITEC has used a material-related laser wavelength to weld electronic components without the addition of any lead based materials. The overall goal of the JOITEC project was to design and build a complete system for lead-free micro welding of micro electronics. This system includes a frequency converted solid state laser and an online inspection system in a machine prototype designed specifically for JOITEC. A robust micro welding process technology has been developed, making it possible to weld spots smaller than 250 μm.

Until now, no commercially available continuous wave green lasers could output enough power for laser micro welding. Using the patented concept of Yb-YAG disk lasers, ELS has developed a new high power continuous wave, 515 nm laser for JOITEC. This laser utilizes two Yb:YAG-crystals in a double Z ring configuration to achieve a maximum power of 50 Watt.

UniKent has developed an online welding quality inspection system. The system monitors the optical emissions from the interaction between the material and the laser during the laser pulse. The signals derived from the welding process are compared with the radiation signature of known results to classify the welding quality. The system has been incorporated into the welding machine and works in real time. This development has significantly reduced the time required for weld inspection and hence increases the efficiency of micro joining. Furthermore MicroLEX has developed two system approaches for visual quality inspection of weldings. One system solution is for off-axis inspection based upon a single, high-resolution image. The other is for on-axis inspection, using smaller focus, but multiple images. However, the final choice of the inspection approaches is governed by the laser access approach and not as much by the quality management system on its own. To complement the new products designed for

JOITEC, an adaptable laser welding process has been developed. New PCB designs made especially for the JOITEC technology have further enhanced the process.
Each piece of the JOITEC technology is available individually, but it is also prepared as a complete package, including end user software and a specially designed machine frame. The software will control everything from laser output, to process parameters and positioning of the laser spot. The machine frame will contain all physical components required for the laser welding process in a single, laser safe environment.
Presentations at the Hannover Messe 2006 and the 3D-MID-Congress 2006 have shown that there is a high demand for such a technology especially for SMEs.

Figure 1.1: JOITEC machine frame prototype

JOITEC is a joint project of Laser Zentrum Hannover e.V. (project coordinator), Bytics Technologie AG, ELS, EPH Electronics AG, ILFA, microLEX Systems A/S, Multisector Norte, and The University of Kent. For contact information of all partners, as well as project flyers and technical updates please visit www.JOITEC.com, or send your inquiries to info@JOITEC.com.

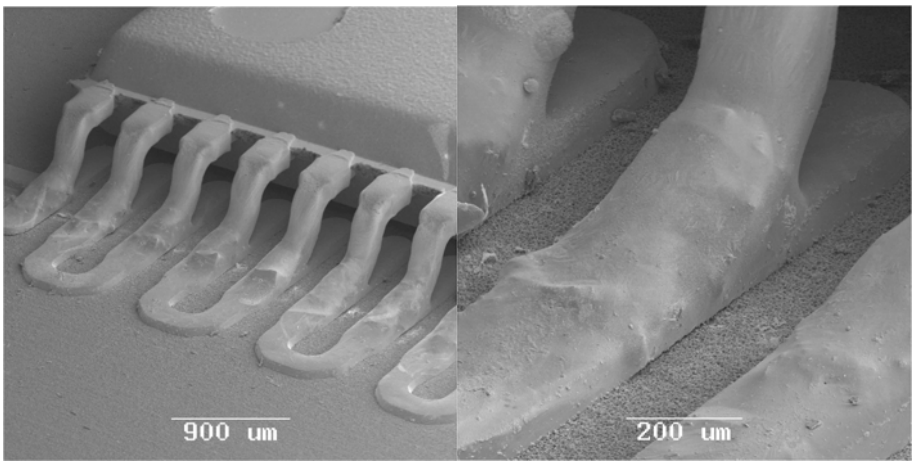

Figure 1.2: First process results of laser micro joining.

Figure 1.3: Logo JOITEC.

2. Dissemination and Use

2.1 Process know-how (Result 1)

2.1.1 Summary

The objective of this work package was to do research work to establish a robust micro welding process.

LZH has made sample investigations of laser spot welding with a 1064 nm ND-YAG laser, of focus diameter 200 – 400 µm. The investigations consisted of laser welding of demonstrator materials, as well as SEM images, polished cross sections and shear tests. Analyses with the shear tester were also performed with soldered demonstrators. The results of these investigations were compared to the results from the 532 nm laser, and to current industrial methods.

Development of a laser source with a wavelength of λ = 515 nm (in the green spectral range) for copper micro welding. The beam profile should reach a high quality (TEM00). When the beam is focused to a very small spot size, a high power density is achieved

2.1.2 Market applications

Figure 4 – Market applications (Result 1)

Possible Market Applications	
Laser spot welding	X
Material processing of non-ferrous and noble metals	X
Annealing and crystallization of glass for LCD displays	X

2.1.3 Stage of development

Figure 5 – Stage of development (Result 1)

Stage of Development	
Scientific and technical knowledge	
Specifications	
Laboratory prototype	
Demonstrator	
Industrial product	X
Results of demonstrations available	

2.1.4 Collaboration sought or offered

Figure 6 – Collaboration sought or offered (Result 1)

Collaboration sought or offered	sought	offered
Manufacturing agreement		X
Finantial support		
Information exchange		
Training		X
Consultancy		X
Partnership		
Other		

2.1.5 Intellectual Property Rights

Figure 7 – IPR matters (Result 1)

Intellectual Property Rights	
Patent applied	
Patent search	
Patent granted	X
Registered design	
Trademark	X
Copyrights	
Secret know-how	X

2.1.6 Contact Details

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2.2 Quality inspection system (Result 2)

2.2.1 Summary

A solution for visual inspection of welded connections, which is based on the development of algorithms to distinguish good weld from failed one, and a mechanical stage for a visual inspection system.

The access for inspection is made through the use of a camera placed out-of-axis of the laser path. In addition, the use of the visual inspection system allows the alignment control of laser placement.

The system includes a prototype software, containing the user interfaces (e.g. Identification of welding spots) and microLEX SuperVISION software tool approach, where out-of-axis image compensation is possible.

2.2.2 Market applications

Figure 8 – Market applications (Result 2)

Possible Market Applications	
Industrial Quality Inspection Systems	X

2.2.3 Stage of development

Figure 9 – Stage of development (Result 2)

Stage of Development	
Scientific and technical knowledge	
Specifications	
Laboratory prototype	X
Demonstrator	X
Industrial product	
Results of demonstrations available	

2.2.4 Collaboration sought or offered

Figure 10 – Collaboration sought (Result 2)

Collaboration sought or offered	sought	offered
Manufacturing agreement	X	
Finantial support	X	
Information exchange		X
Training		X
Consultancy		X
Partnership		X
Other		

2.2.5 Intellectual Property Rights

Figure 11 – IPR matters (Result 2)

Intellectual Property Rights	
Patent applied	
Patent search	
Patent granted	
Registered design	
Trademark	X
Copyrights	
Secret know-how	X

2.2.6 Contact Details

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2.3 System design and implementation (Result 3)

2.3.1 Summary

The validated prototype and the final station contain a laser (wavelength ~ 515 nm) with fibre optic beam guidance, a work head, integrated inspection instruments, and compatible software. The laser and the inspection instruments are controlled by computers.

2.3.2 Market applications

Figure 12 – Market applications for the prototype (Result 3)

Possible Market Applications	
Microelectronics	X

2.3.3 Stage of development

Figure 13 – Stage of prototype development (Result 3)

Stage of Development	
Scientific and technical knowledge	
Specifications	
Laboratory prototype	X
Demonstrator	X
Industrial product	
Results of demonstrations available	

2.3.4 Collaboration sought or offered

Figure 14 – Collaboration sought or offered (Result 3)

Collaboration sought or offered	sought	offered
Manufacturing agreement	X	
Finantial support	X	
Information exchange		
Training		X
Consultancy		X
Partnership		X
Other		

2.3.5 Intellectual Property Rights

Figure 15 – IPR matters (Result 3)

Intellectual Property Rights	
Patent applied	
Patent search	
Patent granted	
Registered design	
Trademark	
Copyrights	
Secret know-how	X

2.3.6 Contact Details

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2.4 Production knowledge (EEMS) (Result 4)

2.4.1 Summary

EPH has done different tests and trials to find out the best solution to fix the components on place on the PCB.

Among the various types EPH has selected two specific sealants from Acc-Silicones (AS1805/AS1824) which fitted best to above mentioned criteria.

2.4.2 Market applications

Figure 16 – Market applications (Result 4)

Possible Market Applications	
Technical Schools	X
Industrial Customers	X

2.4.3 Stage of development

Figure 17 – Stage of development (Result 4)

Stage of Development	
Scientific and technical knowledge	X
Specifications	
Laboratory prototype	X
Demonstrator	
Industrial product	
Results of demonstrations available	X

2.4.4 Collaboration sought or offered

Figure 18 – Collaborations sought or offered (Result 4)

Collaboration sought or offered	sought	offered
Manufacturing agreement		
Finantial support		
Information exchange		
Training		
Consultancy		X
Partnership		
Other		

2.4.5 Intellectual Property Rights

Figure 19 – IPR matters (Result 4)

Intellectual Property Rights	
Patent applied	
Patent search	
Patent granted	
Registered design	
Trademark	
Copyrights	
Secret know-how	X

2.4.6 Contact Details

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2.5 Know-how of the laser welding process working with the pcb materials – copper/surfaces (Result 5)

2.5.1 Summary

New circuit board designs according to a optimised accessibility for the new technology.

2.5.2 Market applications

Figure 20 – Market applications (Result 5)

Possible Market Applications	
PCB Industry	X
Microelectronics	X

2.5.3 Stage of development

Figure 21 – Stage of development (Result 5)

Stage of Development	
Scientific and technical knowledge	X
Specifications	
Laboratory prototype	X
Demonstrator	
Industrial product	
Results of demonstrations available	X

2.5.4 Collaboration sought or offered

Figure 22 – Collaborations sought or offered (Result 5)

Collaboration sought or offered	sought	offered
Manufacturing agreement	X	
Finantial support		
Information exchange		X
Training		
Consultancy		X
Partnership		
Other		

2.5.5 Intellectual Property Rights

Figure 23 – IPR matters (Result 5)

Intellectual Property Rights	
Patent applied	
Patent search	
Patent granted	
Registered design	
Trademark	
Copyrights	
Secret know-how	X

2.5.6 Contact Details

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