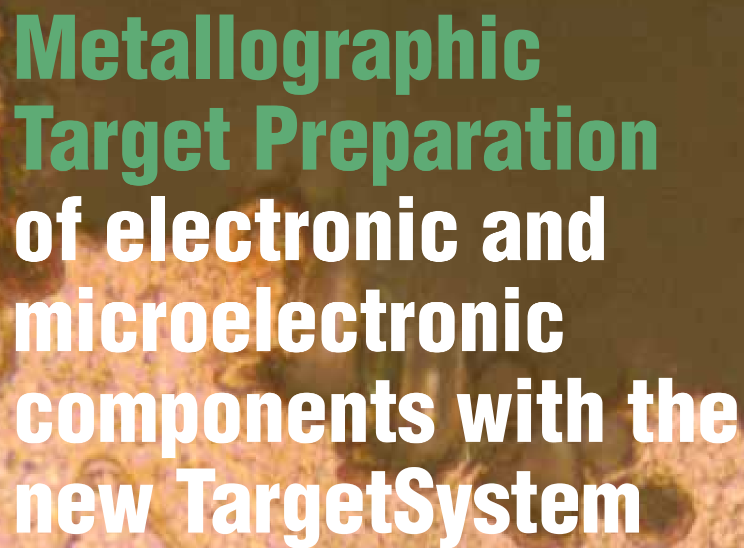


Metallographic Target Preparation of electronic and microelectronic components with the new TargetSystem

Katja Reiter, Jan Lähn,
Fraunhofer Institute for Silicon Technology,
Itzehoe, Germany

STRUCTURE

Struers e-Journal
of Materialography
7/2005

Structure e-7
7/2005

Editorial Board:
Knud Foldschack (responsible)
Bente Freiberg
Michael Rückert

e-Structure is circulated to readers within the field of materialography.

Struers A/S
Pederstrupvej 84
DK-2750 Ballerup
Denmark

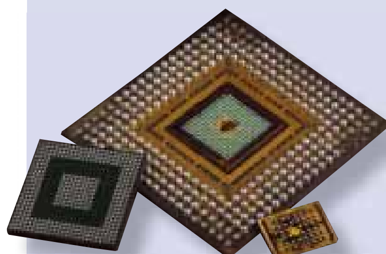
Telephone +45 44 600 800
Telefax +45 44 600 801
e-mail: application@struers.dk
Internet: www.struers.com

Readers are invited to send in written contributions on the preparation of metallographic, mineralogical and ceramic specimens or related subjects.

Articles found suitable will be published free of charge in Structure with any accompanying illustrations in black and white or colour.

Articles should be sent to the editorial board of Structure as paper copy or electronically. If an article is supplied in electronic form, text and images should be saved in separate files.

The following formats are preferred:
Text: MS Word
Images: TIF or JPG in high resolution
Drawings:
Corel Draw (CDR 10 or earlier)
or Adobe Illustrator (AI 9 or earlier)



Metallographic Target Preparation of electronic and microelectronic components with the new TargetSystem

Katja Reiter, Jan Lähn,
Fraunhofer Institute for Silicon Technology, Itzehoe, Germany

Introduction

The progressive miniaturisation of electronic components is increasing the demands regarding their metallographic preparation. Samples of thin gold wires, microvias in multilayer boards, or Area Array Packages such as BGA-, CSP- and Flip Chip-Components are metallographically examined for research and development as well as for failure analysis. This requires extensive metallographic experience as the target areas are mostly hidden by the packaging. A target preparation is only possible by a very careful approach to the target area, often only with blueprints or x-ray photos as a guidance. Therefore it can happen that one grinds past the target area or that it gets lost during the final polishing step.

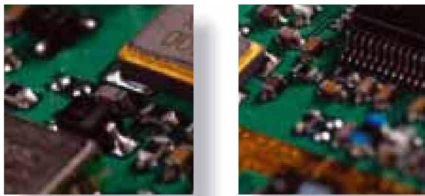
In order to prepare samples easier and without losing them and to make the preparation reproducible, an automatic grinding and polishing machine has been developed: the TargetSystem

In the following the TargetSystem will be described and the development of preparation methods for carrying out a reproducible target preparation is presented.

Description of experiment

To automatically prepare e.g. a 20 µm gold wire bond in an IC, it first has to be located with a microfocus x-ray.
The distance between the edge of the sample and the target plane has to be measured.
The material removal during the individual grinding and polishing steps has to be calculated. The depth of mechanical deformation has to be taken into account. During the grinding step the removal rate has to be checked.
Especially important is the selection of polishing cloths, suspensions and the force used for polishing. These parameters are decisive for achieving clean sample surfaces with good edge retention.
These preparation steps have up to now been carried out manually by metallographically skilled staff.

The TargetSystem is based on the preparation steps mentioned above and should produce reproducible measuring results.



Description of the Device

The TargetSystem is modular and consists of the following components:

- Micropolisher – **TargetMaster**
- Automatic Dosing Station – **TargetDoser**
- Tiltable Sample Holder – **TargetGrip**
- Set-up station for visible targets – **TargetZ**
- Set-up station for hidden targets (used with x-ray system) – **TargetX**

TargetMaster

The basic module, **TargetMaster,** is a micropolisher. An on-board laser measuring system measures the removal on the sample during the polishing process and guarantees a precision of +/- 5 microns. A second, in-line electronic measuring system controls the grinding process continuously.

TargetDoser

The **TargetDoser** is connected to the TargetMaster. It is an automatic dosing system handling up to seven different liquids, such as suspensions and lubricants. It contains a database with a number of standard preparation methods and the capacity to store additional user-defined preparation methods.

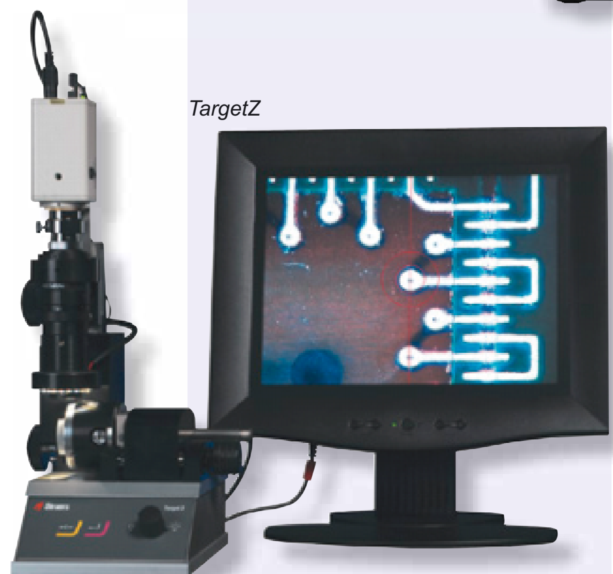
TargetGrip is a specimen holder tiltable up to 5°. The samples are glued onto a support (called sample chair), which in turn is clamped into the TargetGrip. For locating visible targets this specimen holder is mounted into TargetZ or, for hidden targets, into TargetX.

TargetX

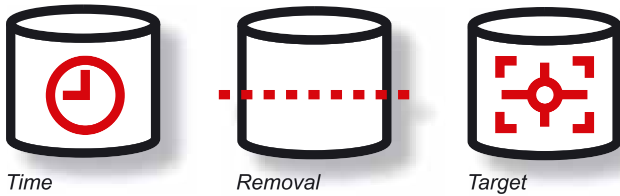
TargetZ is used for aligning and measuring visible targets with a magnification of up to 680x.

TargetX is used for non-visible targets and consists of a set-up station and a console. The former is to be installed into an x-ray. The console allows remote-controlled real-time alignment and measurement of the specimen inside the x-ray.

TargetZ



TargetGrip



TargetMaster offers three preparation modes, which can be combined individually.

1. Target Mode: for polishing the sample until the measured target plane has been reached.

2. Removal Mode: for manually setting the amount of material to be removed, e.g. when rows of microvias on a printed circuit board are to be prepared successively.

3. Time Mode: for polishing for a specified period.

Development of Preparation Methods:

For the metallographic preparation, the electronic components have been divided into two groups:

Group 1: Components with aluminium oxide ceramic (e.g. SMD-resistors, unmounted PCBs)

Group 2: Components with fragile parts that are prone to artefacts (capacitors, glass diodes, silicon etc.)

For the preparation the following parameters are important:

- Mounting resin
- Grinding/polishing discs and cloths
- Polishing suspension
- Polishing force

The development of a method for samples of Group 1 is presented using a MELF-resistor with a ceramic core as an example (Sample 1+2). Using instant glue the sample is fixed to the centre of a sample chair. The sample chair is clamped into the sample holder Target-Grip, which is introduced into TargetZ where the sample is aligned and measured. The measured data is transmitted to the TargetMaster. Now the sample is protected by covering it with epoxy mounting resin. Fig. 2 shows the sample holder in TargetZ.

For developing the preparation methods the force was adjusted and several polishing cloths and suspensions tested, using the commonly available consumables. The parameters giving the best results are listed in Table 1.

Fig. 3 and 4 show the results of different grinding methods.

Fig. 2: TargetZ with sample holder

Fig. 3: Sample 1 ground with SiC-Paper #800

Fig. 4: Sample 2 ground with Diamond Pad 20 µm

Step	1	2	3	4	5
Surface	Diamond Pad	MD-Largo	MD-Dur	MD-Dur	MD-Chem
Abrasive	Diamond	DiaPro Largo	DiaPro Dur	DiaPro NapR	OP-S
Grit/grain size	20 µm	9 µm	3 µm	1 µm	
Lubricant	Water				
rpm	300/150	150/150	150/150	150/150	150/150
Force	35 N	20 N	15 N	15 N	10 N
Time				1 min	0.5 min
Removal		20 µm	10 µm		

Table 1: Preparation method Group 1

Sample 1 (Fig. 3) shows edge rounding as the area between wire and solder is not clearly defined.

In Sample 2 (Fig. 4) the area between wire and solder can be clearly distinguished.

The difference lies in the grinding step: Sample 1 was ground on SiC paper # 800 and Sample 2 with Diamond Pad 20 µm. Diamond Pad is thus our choice for grinding electronic components from Group 1.

The effect of different polishing cloths is shown in the development of preparation parameters for the samples of Group 2.

The sample, a wafer-level-package of silicon substrate with SnPb solder balls, was polished with a Dac-cloth and compared with the polish on a Dur-cloth (Sample 3+4). In both cases the abrasive was the DiaPro-Dur diamond suspension. The polish on the Dac-cloth caused an artefact: the silicon substrate fractured in the contact area to the solder ball. Polishing with the Dur-cloth did not cause any fractures. (See Figs. 5 and 6)

This shows that the diamond suspensions that are especially designed to be used with specific cloths give very good results. This is demonstrated in Fig. 6b, which shows the grain structure of sample 4 with polarized light.

For components with fragile materials it is very important to choose the correct force for polishing. If the force is too high it can cause fractures and pull-outs, which may lead to incorrect interpretations.

Table 2 shows the data for the best preparation method for samples from Group 2.

Step	1	2	3	4	5	6
Surface	MD-Fuga	MD-Fuga	MD-Largo	MD-Dur	MD-Dur	MD-Chem
Abrasive	SiC	SiC	DiaPro Largo	DiaPro Dur	DiaPro NapR	OP-S
Grit/grain size	800	1200	9 µm	3 µm	1 µm	
Lubricant	Water	Water				
rpm	300/150	300/150	150/150	150/150	150/150	150/150
Force	30 N	30 N	20 N	15 N	15 N	10 N
Time					1 min	0.5 min
Removal		300 µm	20 µm	10 µm		

Table 2: Preparation method for Group 2

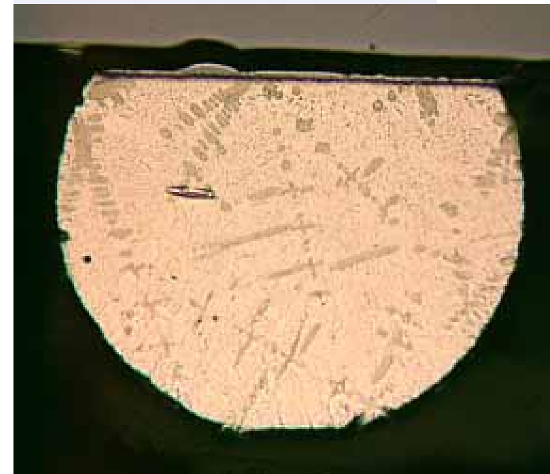


Fig. 5: Sample 3 polished with Dac-cloth. (Brightfield)

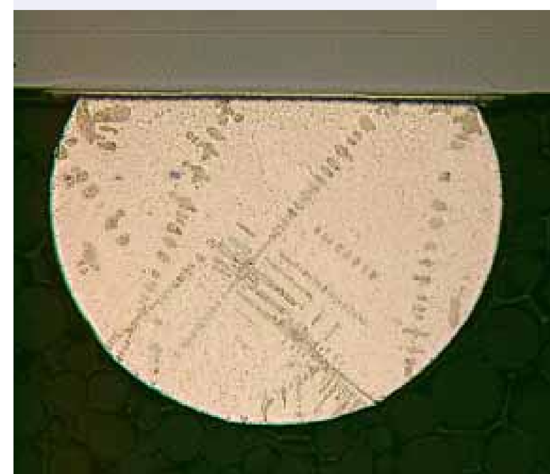


Fig. 6a: Sample 4 polished with Dur-cloth (Brightfield)

Fig. 6b: Sample 4 polished with Dur-cloth (Polarized light)

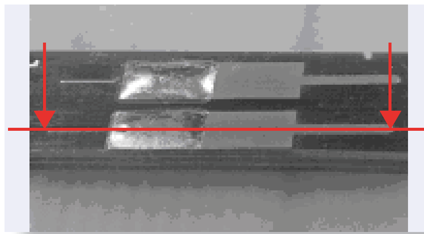


Fig. 7: Overview PCB
(Arrows indicate cross section area)

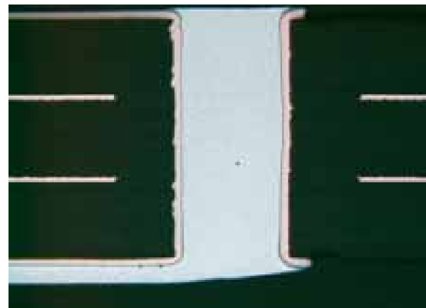


Fig. 8:
Cross section
of plated-
through hole

Sample	1	2	3	4	5	6
	Removal (µm)	Removal (µm)	Removal (µm)	Removal (µm)	Removal (µm)	Removal (µm)
SiC #800	1691	1653	1697	1622	1677	1682
SiC #1200	261	260	256	254	253	255
MD-Largo 9 µm	19	15	12	28	26	22
MD-Dur 3 µm	2 min	2 min	2 min	2 min	2 min	2 min
MD-Dur 1 µm	1 min	1 min	1 min	1 min	1 min	1 min
OP-Chem 0.25 µm	0.5 min	0.5 min	0.5 min	0.5 min	0.5 min	0.5 min
Target Value	1971	1926	1965	1899	1958	1961
Distance to target	2	-2	0	-5	2	2
Time	44 m 26 s	44 m 52 s	45 m 1 s	46 m 25 s	41 m 52 s	42 m 56s

Table 3: Process Summary for 6 samples

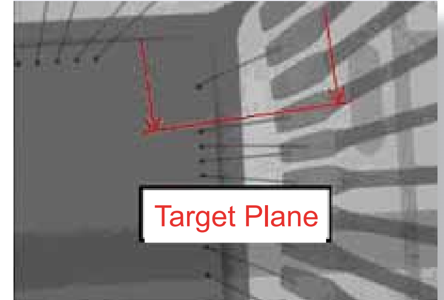


Fig. 9a: Radiographic image of chip-on-board component with gold ball-wedge-bond, diameter 20 µm. Measured with Target X

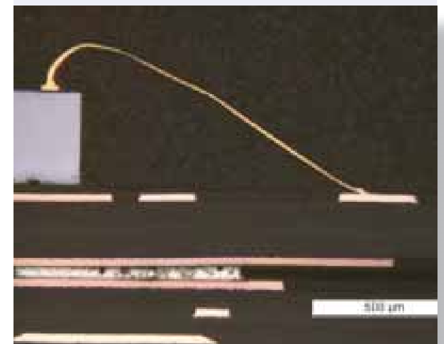


Fig. 9b: Microsection of gold-ball-wedge-bond, full length of bonding wires

To test the reproducibility of precision regarding the target plane, cross sections of a PCB with a plated-through hole each were prepared. (Figs. 7 and 8)

Table 3 shows the process data (Process Summa ry) for 6 different samples, which were automatically recorded and displayed by the TargetSystem, the method used was the one for Group 2. The average deviation from the target plane (Distance to target) was approx. 2 µm.

This demonstrates that the process of targeting and showing the preparation planes is reproducible. The difference in process time results from the wear of the Diamond Pad and polishing cloths, and the distance from the target plane.

The following micrographs show additional samples, which were prepared with the TargetSystem.
The cross sections are examples from the wide range of interconnection technologies for electronic components.

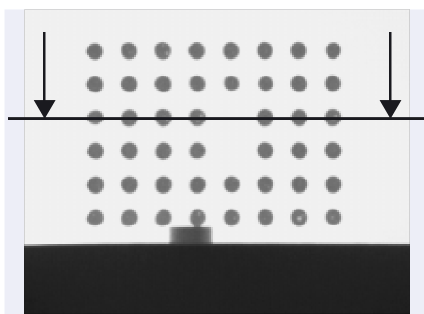


Fig.10a: Overview: CSP-component aligned and measured in x-ray using TargetX (arrows indicate cross section area)

Fig.10b: Cross section of solderball bumps, eutectic SnPb-solder (detail of Fig.10a)

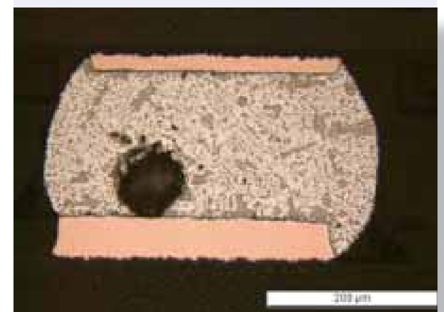
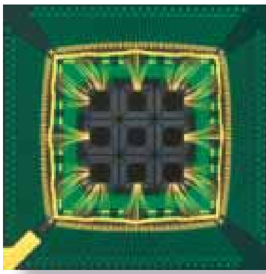


Fig.10c: Microsection of solder ball, eutectic SnPb-solder (detail of Fig.10b)



Summary

The TargetSystem has been described and preparation methods for achieving good sample surfaces were developed. The TargetSystem is suitable for metallographic failure analysis of electronic and micro-electronic components.

The desired preparation planes of several similar samples were reached precisely and the process was reproducible. To manually prepare these samples with good quality surfaces is difficult and time consuming and can only be done by experienced metallographers. In manual preparation there is always a risk of grinding past the target after which the specimen is irrevocably lost.

After an introduction and a brief training period, it is possible to prepare difficult samples with the TargetSystem within short time, with high precision and good reproducibility.

Literature

Brochure TargetSystem, Struers A/S, Copenhagen, Demnark
Structure reprint: Metallographic Preparation and Microstructures of Electronics and Microelectronic devices, F. W. Wulff, T. Ahrens, K. Reiter, Fraunhofer Institute for Silicon technology, Itzehoe, Germany

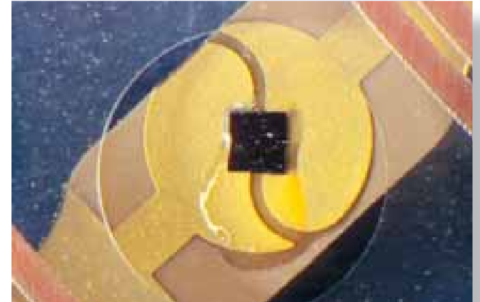


Fig.11a: RF-Transponder-Chip (Flex-Si, 50µm) in Smart Card

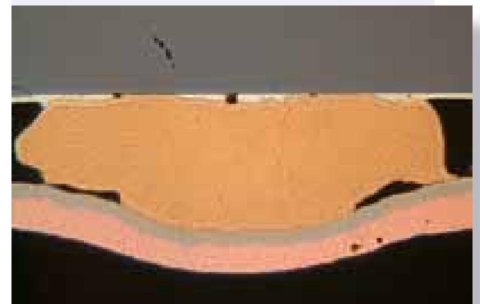


Fig.11b: Contact zone for connection of Flex-Si-Chip (Stud-Bump) and Chip card metallization (Cu-Ni-Au)

Fig.12a: Overview: Thermally cycled Si Chip joined to lead frame with conductive adhesive - Au ball bonds on Si Chip

Fig.12b: Detail: Au-ball-bond (diameter 20µm); Al-metallization consumed by intermetallic phase growth