EDAX FOCUS

EBSD Based Analysis of Lead-Free Solders

Inside This Issue

Introduction

One of the challenges of the electronic packaging industry is to move from traditional lead based solders to lead-free solders in order to reduce the use of toxic materials. However, one of the obstacles to moving to lead-free solders is cracking of the solder joints. Current characterization tools being used to solve this problem are basic SEM imaging and EDS. EBSD offers new possibilities for characterizing cracking in solders. Often SEM imaging suggests that the cracks are intergranular, that is, they propagate at grain boundaries. However, this is not always obvious from SEM images alone. EBSD can unambiguously identify cracks as intergranular or transgranular. In addition, statistical analysis of grain boundaries can identify the types of grain boundaries that may be susceptible or resistant to cracking. EBSD is also capable of identifying areas of high local orientation variations which are indicative of the buildup of localized residual strain. If the stress state can be accurately determined then the anisotropy of elastic stiffness or incompatibility at grain boundaries can also be modeled. Such analyses done over a matrix of specimens can help identify potential process improvement opportunities.

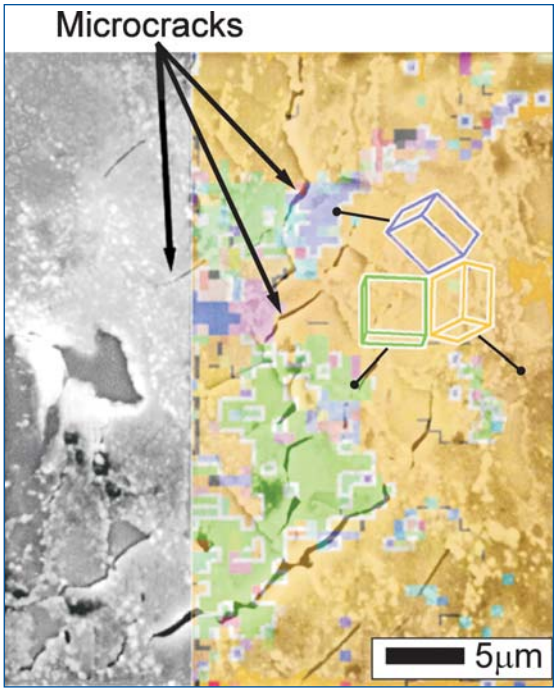

Figure 1 – Micrograph of a lead-free solder partially overlaid with an orientation map. Colored tetragons show the orientation of the colored regions in the map. (Courtesy of T. Bieler – Michigan State University)

In order to illustrate some of the potentials of OIM™ in the study of fracture problems, we show the application of EBSD to cracking in several different material systems. (Cont'd on Pg. 3)

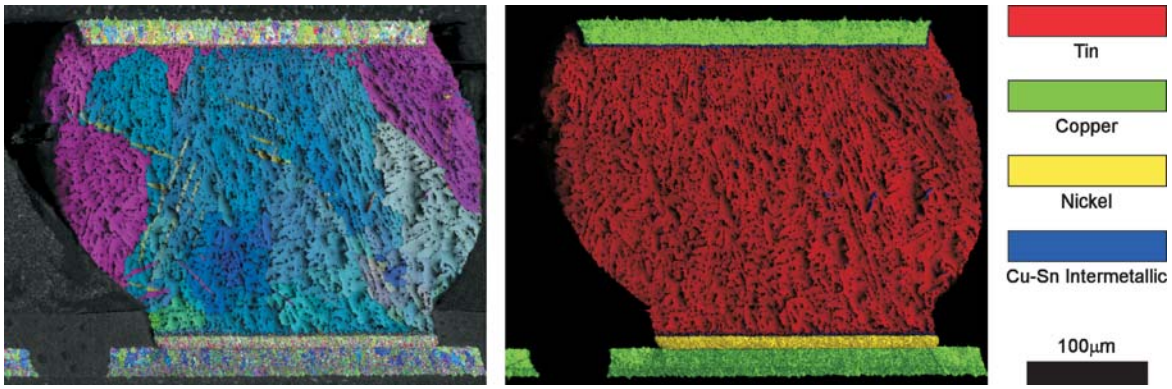

Figure 2: Orientation map and phase map from a lead-free solder bump.

TIPS & TRICKS

Generating Micro-XRF Overlay Maps

The spectral mapping option in the EDAX Vision software for Eagle and Orbis μ-XRF systems allows collection of spectral data from a matrix of points in a selected sampling area for a given list of elements. By using a color palette to associate each element's intensity, a visual representation of the elemental distribution can be attained for each element. The option for a live "Color Overlay" display exists in the collection window, where the first six elemental maps can be combined into one overlay map. In it, each data point will instead represent only the element with the highest relative intensity. In order to save a version of this map and generate a report, the user must access the "Image Display & Processing" software, also called "IDX," which is in the EDAX32 folder.

Once "IDX" is initiated, display the saved .BMP image maps by selecting "File" > "Open," and double-clicking on any one of the maps. Hold down "Control" to select up to six individual elemental maps for the overlay. Keep in mind not to select two elements that have the same palette color. To change a map's color, select "Edit" > "Image Parameters" from the upper menu, and in the "Color" drop down, select a different color, and click "OK." Once the colors and maps have been selected, click "Process" > "Color" > "Substitution Overlay" from the upper menu bar. This will immediately create and display the overlay map within the display window, as highlighted in Figure 1. Select this overlay map with a single click, and save it as a .BMP under "File" > "Save As."

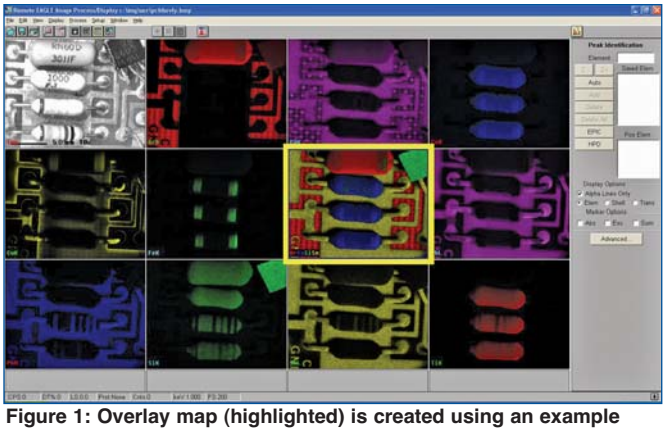

Figure 1: Overlay map (highlighted) is created using an example with Br, Co, Si, Sn.

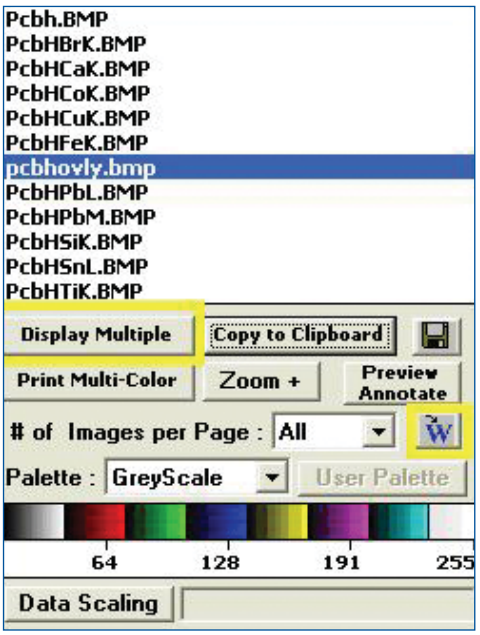

Figure 2: Spectral Utilities functions to display overlay, and generate a report.

To generate a Word report with the newly saved overlay, open the "Spectral Utilities" software from the EDAX32 folder. From the top menu, select "Image-Utilities," and it will prompt the user to open a set of maps. Double-click the previously saved overlay map, and it will be opened within the Image Bitmap Viewer window. Select the file, and click "Display Multiple" (highlighted above in Figure 2) which displays the overlay map. Click the Word reporting icon (highlighted above), and the report will be generated, as seen in Figure 3.

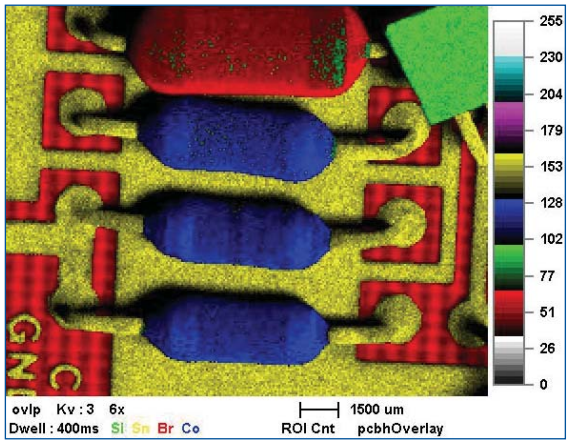

Figure 3: Color overlay map as it is displayed in the Word report, with a color-coded element legend.

EBSD Based Analysis of Lead-Free Solders (Cont'd. from Pg. 1)

Sample Preparation

EBSD is very much a surface sensitive technique sampling only 10 to 20nm in to the depth of the sample. Thus, in order to get good EBSD data it is imperative to have a well prepared sample surface. Lead-free solders pose some particular difficulties for sample preparation for EBSD due to the softness of the solder, and the relative hardness differences between the solder alloy, the contact metal layers, and the intermetallic phases present. Often polishing times and forces will need to be reduced for optimal results. In addition, polishing to the correct plane within the sample can be difficult. A procedure recommended by Allied High Tech Products, Inc. is listed in Table 1. Providing an adequate path to ground during analysis to minimize charging effects can also be problematic. Often samples are embedded in a non-conductive epoxy to facilitate preparation. This provides a large non-conducting volume around the sample. One approach is to sputter deposit a thin (25-35Å) conductive carbon layer over the sample surface. However careful control of the film thickness is required to minimize EBSD pattern degradation. Another approach is to use a conductive paint (carbon or silver) to cover most of the sample surface area except for the region of interest. This can be accompanied by a thinner (10-15Å) carbon coat. A third approach is to add conductive filler to the epoxy; however this can make sectioning to the desired plane more difficult. A fourth option, if applicable, is to use the low vacuum analysis capability available on many modern SEMs.

Step	1	2	3	4	5	6
Abrasive	320 Grit SiC Grinding Paper	600 Grit SiC GrindingPaper	6μm Polycrystalline Diamond Suspension	3μm Polycrystalline Diamond Suspension	1μm Polycrystalline Diamond Suspension	0.05μm Colloidal Silica
Polishing Cloth	NA	NA	Gold Label	White Label	Vel Cloth	ChemPol
Coolant	Water	Water	GreenLube	GreenLube	GreenLube	Water
Platen Speed	250 RPM Complementary	250 RPM Complementary	150 RPM Complementary	150 RPM Complementary	150 RPM Complementary	150 RPM Complementary
Pressure	10 lb/F	10 lb/F	8 lb/F	8 lb/F	8 lb/F	5 lb/F
Time	2:00	2:00	6:00	3:30	3:30	2:00
Polishing Head Speed	150 RPM	150 RPM	150 RPM	150 RPM	150 RPM	150 RPM

Table 1 - Sample Preparation Procedure for Lead-Free Solders (Allied High Tech Products, Inc.)

Welcome to EDAX

Figure 1: EDAX Headquarters, Mahwah, NJ.

If you have ever had the occasion to visit the EDAX facility in New Jersey, you more than likely visited the EDAX Laboratories for a product demonstration or our training room for system instruction.

The EDAX facility not only provides training, but numerous other departments are located at the corporate office. Finance, Logistics, Purchasing, Engineering, Software Development and Applications Support, as well as a 25,000 square foot factory assembly, shipping, and warehouse area are located here well. Other departments that our customers have probably had contact with include Sales and Marketing and Service and Technical Support. This is all in addition to our Applications Laboratories, which are the first and sometimes only area that our customers see.

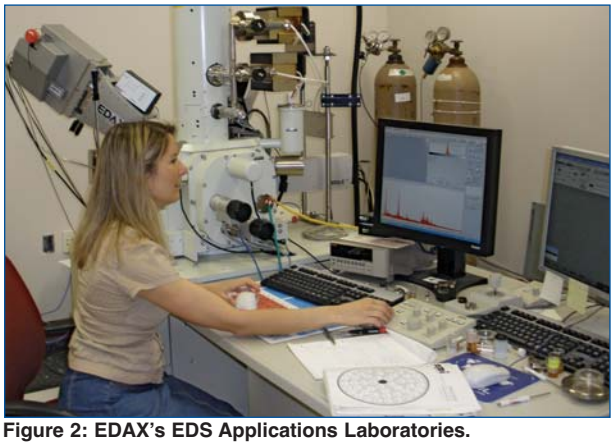

Figure 2: EDAX's EDS Applications Laboratories.

The Sales and Marketing Departments have many years of technology and product management experience among them. It is here that a direct line to our field sales team and customers is established to provide valuable information for use in consideration of current and future product development as EDAX expands into new markets.

EDAX's Service and Technical Department prides itself on an excellent technical and customer support infrastructure. The quality of the technical support team is appreciated and recognized by both EDAX and our customers. In this department you will find many EDAX system models in various stages of disassembly. These systems allow our support team to have a hands on approach to the systems and best describe the procedures and processes to either a Field Service Engineer or directly to a customer.

Figure 3: The Technical Support team.

The Engineering and Software Development groups within EDAX are busy designing and developing new innovative products. In the Engineering area one will find new product components being developed that will one day become the next generation EDAX system. In the Software Development area, new capabilities are written into software code and technologically advanced software is designed.

All of the departments within EDAX's corporate office work closely to provide our customers with the best product and service available to the materials characterization community today.

Join EDAX for Monthly Web Seminars

On May 7, 2009, EDAX began hosting a series of microanalysis Web Seminars that offer a first hand education on microanalysis technologies available today. The seminars take place on the first Thursday of every month at 2:30 EST and run approximately one hour long with time allowed for questions and answers. Please note, time or schedule may be subject to change.

Future Topics:

Introduction to Silicon Drift Detectors (SDD) – July 2, 2009
The EDS trend has been moving towards SDD capabilities for dramatic increases in collection capabilities, electronics, and throughput. The benefits extend from spectral collection with confident results in seconds, to mapping collection at over several hundred thousand Counts Per Second (CPS) and more without sacrificing resolution or low energy performance.

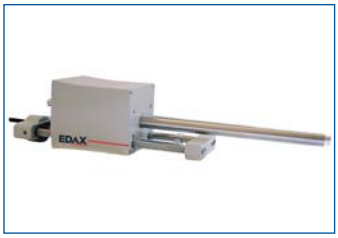

Figure 1 – Apollo Silicon Drift Detector.

Introduction to Electron Backscatter Diffraction (EBSD) – August 6, 2009
EBSD is becoming increasingly prevalent in many industries as a compliment to EDS analysis. EBSD will allow the user to identify and characterize crystal structure information at every point in a sample and generate maps with grain information (boundary, sizing, etc), orientation information, structural phase differentiation, texture data, and much more.

Figure 2 – Schematic of EBSD detector, sample and electron beam geometries in SEM chamber.

Previous Topics:

What is New in Genesis?
The newest software features within the Genesis EDS software. New features include enhanced mapping and multipoint capabilities as well as EXpert ID, which is used to obtain the most from your Auto ID routine.

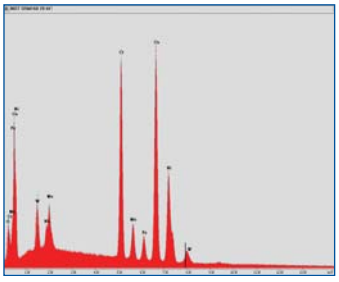

Figure 3 – Example of EXpert ID, automatically and accurately identifying the peaks within the spectrum.

Introduction to μXRF - The EDAX Orbis μXRF
The Orbis is a standalone tool, which is incredibly valuable for nondestructive testing in a wide range of applications including forensics, petrochemical, semiconductor, aviation, transportation, and more. Benefits of μXRF include increased sensitivity for many elements greater than K(K) energy, little to no sample prep for dirty, insulating or wet samples, and a greater range of sample sizes and types. Paired with an optical microscope, the user can identify the area of interest and collect from a small region (down to 30-micron spot) all the way up to maps 10 to centimeters square.

Figure 4 – Orbis Micro-XRF Spectrometer.

EDAX customers are encouraged to attend our Web Seminars. If you would like to participate, please contact EDAX at edax.applications@ametek.com and EDAX will provide you with login information. Logging in is as simple as logging onto a website link and calling a toll free number. This new offering is available to all EDAX users and is free of charge. Take this opportunity to learn more about your EDAX product(s).

TRAINING AND EVENTS

World-Wide Events

July 27-30	Denver X-ray Conference	Colorado Springs, CO
July 27-30	M&M (Microscopy & Microanalysis)	Richmond, VA
August 25-29	THERMEC 2009 (International Conference on Processing & Manufacturing of Advanced Materials)	Berlin, Germany
August 30 - September 4	Microscopy Conference (MC) 2009	Graz, Austria
September 2-4	JAIMA Show	Makuhari, Japan
September 8-11	Electron Microscopy of Analysis Group (EMAG) 2009	Sheffield, UK
September 14-18	The 20th International Congress on X-ray Optics and Microanalysis (ICXOM20)	Karlsruhe, Germany
September 16-18	Metallographietagung	Aachen, Germany
October 18-22	Southern Association of Forensic Scientist (SAFS Fall)	Orlando, FL
October 25-29	MS&T (The Materials Science & Technology Exhibition) Formerly called ASM	Pittsburgh, PA
October 28-29	Fall 2009 California Associations of Criminalist (CAC Meeting)	San Jose, CA
December 1-3	MRS (Materials Research Society)	Boston, MA

***Please see our website, www.edax.com for a complete list of our tradeshows

World-Wide Training

To help our present and potential customers obtain the most from their equipment and to increase their expertise in EDS microanalysis, WDS microanalysis, EBSD/OIM and Micro-XRF, we organize a number of Operator Courses at the EDAX facilities in North America; Tilburg, NL; Wiesbaden, Germany; and Japan.

Europe

Tilburg = (T) (in English)
Wiesbaden = (W) (in German unless stated otherwise):

Microanalysis Courses:
3-4 Day

- September 28 - October 1 (T)
- November 17-26 (W)
- November 23-26 (T)

2 Day

- September 17-18 (T)
- November 12-13 (T)

LEX Course: 3 Day

- October 13-15 (T)

Pegasus Courses:

- September 14-18 (T)
- October 19-23 (W)

OIM™(EBSD) Courses:

- September 14-16 (T)

Japan

Microanalysis Courses:

- July 1-3 Osaka
- October 7-9 Tokyo
- November 11-13 Osaka

For more information on our training classes, please visit our website at:
www.edax.com/service/user.cfm

North America

Microanalysis Courses:

- July 14-16 Draper, UT
- August 10-14 Mahwah, NJ
- September 14-18 Mahwah, NJ
- October 19-23 Mahwah, NJ
- December 7-11 Mahwah, NJ

Particle Course:

- November 10-12 Mahwah, NJ

EBSD OIM™ Academy Course:

- September 1-3 Mahwah, NJ
- October 13-15 Draper, UT

Micro-XRF Course:

- October 6-8 (Orbis only)

EMPLOYEE SPOTLIGHT

Beverlee Boddy joined EDAX in 2004 as a Marketing Administrative Assistant. This past year, Beverlee was promoted to her present position, Marketing Support Representative, based out of the EDAX corporate headquarters in Mahwah, New Jersey. Beverlee was born in Ridgewood, NJ and moved to Glen Rock, NJ at a young age. She graduated from The Berkeley School (now called Berkeley College), which was located in Ridgewood, NJ, with a Business Certificate and also attended William Paterson University, located in Wayne, NJ where she received a Project Management certificate in their Continuing and Professional Educational program. She has also taken several IT and Business courses throughout the years while she was employed at IBM for 19 years.

Beverlee is an integral part of the Marketing team at EDAX. She has several responsibilities in the department including the layout and design of the EDAX FOCUS newsletter, administrator of EDAX's Customer Relationship Management system (Ardexus), administrator of the EDAX website, and electronic emails. In addition to her Marketing responsibilities, she coordinates the EDAX User Schools and assists the IT department when needed. Beverlee is very efficient, versatile, and concise and is relied upon by her colleagues to assist them in projects throughout the company.

Beverlee and her husband Mert enjoy spending time with family, motorcycle riding, and traveling. One of their most memorable trips was taken in 2006. They traveled from New York to Chattanooga, Tennessee. Once they reached Tennessee, they participated in the yearly "Trail of Tears Remembrance Motorcycle Ride" to Florence, Alabama.

Dr. Kip Goi is the Application Support Engineer for Southeast Asian. Kip's territory was expanded this year to include India, Taiwan, and Australia. Kip was born and raised in Singapore. Shortly, after graduating from the University of Birmingham from Midland, UK in 2001, he returned to Singapore where he received a scholarship from Nanyang Technological University for his Master Degree by Research in 2002. Later he developed an interest in R&D where he was bestowed a chance for a Doctorate of Technology Engineering from Royal Institute of Stockholm. He completed his Doctorate in 2007, while working for EDAX as a Service Engineer and studying part-time.

In 2004 Kip was employed by AMETEK Singapore to take charge of the servicing and installation of the EDAX products. Kip is responsible for scheduling travel plans for both the service and installation teams as well as providing application training for the support team.

Kip enjoys his favorite past-time hobby of discus keeping. Discus (Symphysodon) are a genus of three species of freshwater cichlid fishes native to the Amazon River basin. Kip has had this hobby for the past 18 years. Due to his extensive traveling schedule he has given up this hobby recently but he is still enthusiastic about it. When he travels overseas, he will visit the local breeders and get updated with what they are presently breeding.

CUSTOMER NEWS

Microtechnics, Granite Bay, CA

Microtechnics is a contract company for analytical and design services specializing in the area of semiconductor and solid-state systems for the military.

Housed in their facilities is an EDAX Pegasus with an A40 Silicon Drift Detector (SDD) combined with a Digiview camera on a Zeiss Supra. They have used the system for over five years but have used EDAX for much longer.

Gary Gaugler is the primary user of the system. Previously employed by Wright Patterson Air Force Base in Dayton, OH, Gary transferred to McClellan AFB in Sacramento, CA. Gary's initial assignment was opening a facility within McClellan whose charter was to prolong the offering of semiconductor devices being obsolete by their original manufacturer. Initial work was done on bipolar devices. However, the group's charter expanded to include board level systems requiring redesign to accommodate new replacement devices.

Gary is a PhD level scientist with a background in semiconductor design, manufacturing, and reliability statistics. At the present time, Microtechnics is contracted by the military to redesign older electronic systems such that they are operational with today's electronics. In addition Gary uses Electron Backscatter Diffraction (EBSD) as a means of predicting device reliability. As a contractor to the military, Gary travels worldwide to semiconductor suppliers presenting the use of EBSD in reliability models. Gary has several publications in the area of reliability and EBSD most recently in 2008 issues of both Microscopy Today and Scanning.

Microtechnics believes EDAX's service and support is top of the line. The EDS and EBSD tools are both powerful tools. EDS with an intuitive interface, and EBSD with endless database manipulation. Gary initially purchased his system with a Si(Li) EDS detector but later upgraded to the A40 SDD.

Gary states, "Our relationship with EDAX is great and we would recommend EDAX".

Art & Layout:
Beverlee Boddy
Christine Meehan

Correction: Vol.7 No.1 Page 3 **Figure 2: 1.5x1.5mm scan of nickel at 50x. As the beam deflects over larger areas, the WD is effectively lengthened, and the focus is no longer appropriate.**

Contributing Writers:
Dr. Kip Goi
Jim Hardy
Andrew Lee
Tara Nylese
Dr. Stuart Wright

AMETEK MATERIALS ANALYSIS DIVISION

EDAX advanced microanalysis solutions

EDAX Inc. ● 91 McKee Drive Mahwah, NJ 07430 ● Phone: (201) 529-4880 ● E-mail: info.edax@ametek.com ● www.edax.com