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Fuel Cell Manufacturing Challenges

The U.S. warfighter utilizes high performance electronic systems to gain tactical advantages while in the field. As these systems advance technologically, their power consumption increases as well. This has increased the demand for inexpensive, small, lightweight, moveable, and quiet energy sources. While batteries can fill the power needs below 200 watts and generators can fill power needs above 500 watts, the 300 watts power niche for non-stationary power is not easily filled. Fuel cells have the potential to fill this technology gap between batteries and generators for a low power, extended run time, silent power source (Table 1-1).[1]

The challenge for the warfighter disconnected from grid power or vehicle is to carry enough primary batteries or rechargeable secondary batteries during missions that last longer than a few days. Recharging stations need a fueled military tactical generator (the smallest is a 2 kW, 138 pounds, and 6 cubic feet) which must also be transported by the soldier. Fuel cells are an alternative that can be made for smaller power ranges and are lighter than generators.[2]

Remote sensors and silent watch must be quiet and have extended run times. While batteries need to be recharged or replaced and generators are noisy, fuel cells are both quiet and can be quickly refueled for extended run times. Their run time is only dependent on the size of the fuel tank.

In comparison to batteries, fuel cells can provide the smaller volume and lower weight needed for an unmanned aerial vehicle such as the Navy's Ion Tiger (Figure 1-1). Equipped with a tank of compressed hydrogen, fuel cells can also provide longer run times.[3]

Figure 1-1: The Navy's Ion Tiger UAV.

Fuel Cell Advantages

Fuel cells offer greater fuel efficiencies than generators allowing increased power efficiency and reducing the burden of fuel transportation to remote locations. The theoretical fuel cell efficiency estimates are as high as 83% compared to the efficiency of a traditional JP-8 (a kerosene-based jet propellant) fueled generator at 16 to 20%. For warfighter-carried reformed methanol fuel cell systems, the actual efficiencies are lower at only 24%.[2]

Fuel cells also produce lower exhaust emissions than generators for carbon monoxide, carbon dioxide, hydrocarbons, nitrogen oxides (NO_X), and sulfur oxides (SO_X) and can be considered for indoor applications without dedicated exhaust pipes. Run times can be extended by using larger fuel tanks or by switching fuel tanks.

To become commercially viable beyond niche applications, the price per kilowatt must be near the price point of batteries and generators. Currently, automotive combustion engines cost approximately $25 to $35 per kW. For expanding fuel cell applications, the price point is $400 to $750 per kW with the ultimate goal of $30 per kW.[4]

continued on page 7

Ask the EMPF Helpline!

Ball Grid Array (BGA) Voiding Affecting Functionality

A customer recently contacted the EMPF Helpline in regards to a high failure rate of their assemblies.

A customer provided assemblies to be X-rayed and inspected for the purpose of identifying any process related issues such as (but not limited to) solder and assembly workmanship and evidence of damage due to moisture related problems during reflow (a.k.a. "popcorning").

Figure 2-1: Image of component with fractures to the outer surface due to moisture related problems during reflow.

Moisture damage usually appears as physical damage to the component. The first indication of moisture damage would be externally observable changes to the package in the form of bulging or fractures to the outer surface of the component, an example of which is shown in Figure 2-1. Internally observable indicators of moisture damage typically include fractures to the die inside the package and lifted or fractured wire bonds. These conditions would be apparent during transmissive X-ray inspection. Another symptom of moisture related damage would be inconsistent solder joint sizes that result from package deformation during the liquidus phase of the reflow process. None of these indicators of moisture related damage were present on the customer samples.

No issues were observed with the large BGA components on the assemblies. Representative via X-ray inspection images (Figure 2-2) show that the die, wire bonds, and solder balls appeared well-formed and provided no indication as to a loss of functionality.

For the smaller BGA style components, assembly and solder workmanship issues were identified as shown in Figure 2-3. Specifically, the elevated level of voiding in the solder joints on the 54-pin memory components was identified as a potential contributor to failures. IPC A 610E specifies voiding that exceeds 25% of the X-ray image area is a defect for all classes of production. The EMPF recommended that any voiding that exceeded 10% of the ball X-ray image area be treated as a process related process indicator condition (i.e. a condition that indicates excessive variation from the intended result). Although detailed voiding analysis was not performed on these samples, it was apparent from visual inspection that there were many solder joints on these parts that exceeded the 10% recommended limit. Many of the voids appeared to be at an interface which may have contributed to signal issues. The sizes of the voids also may have interfered with long term reliability.

In addition, the location of voids in a BGA solder joint can be critical, regardless of the void size. Voids that occur at the solder joint/printed circuit board (PCB) land interface ("interface voids") can impact the reliability of the resulting solder joints. This occurs because the yield strength of a solder joint is related to the surface area of contact between the solder and the surfaces it joins. Interface voids reduce this contact area and can lead to mechanical failure of the solder joint. Some solder joints, such as those viewed in Figure 2-3, appeared to have voids that occurred at the interface and have reduced the wetting contact areas on the PCB.

Voiding can be a result of a variety of causes which include the properties of the flux used on the assembly and the profile used to reflow the solder paste. Interface voids can also be a result of a non-wetting or dewetting condition on the PCB land.

No other assembly workmanship issues were detected during the inspection performed on these assemblies. Voiding that occurred on components other than the 54-pin memory was minor in nature and fell within the expected amount of voiding on a well-formed BGA solder joint. All solder joints (except those noted) showed evidence of good collapse and wetting to the PCB lands as would be expected on a well-formed BGA solder joint.

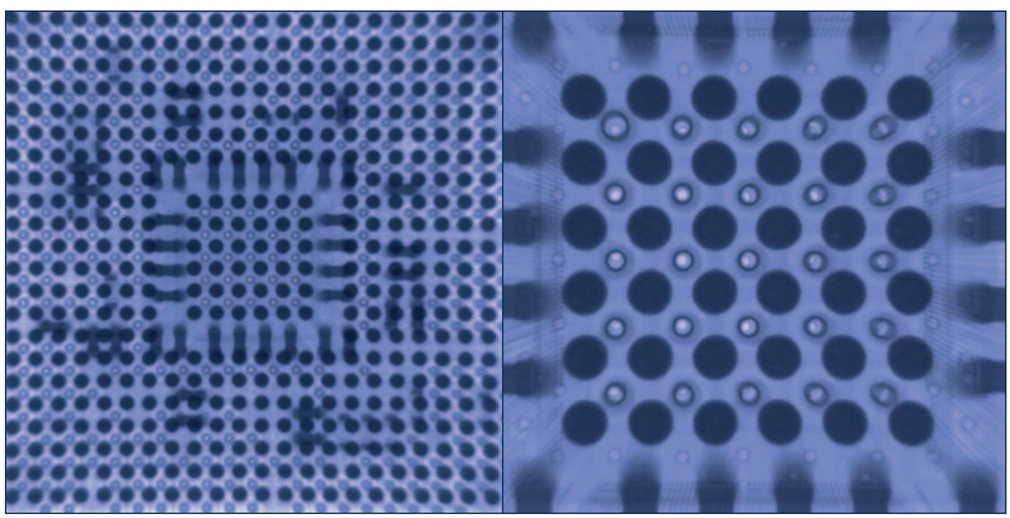


Figure 2-2: X-ray images of a large BGA component; left is whole component with minimal voiding, right is a view of the die with wire bonds intact and with minimal voiding of the solder balls.

continued on page 9

Optimizing Fuel Cell Performance

At the Naval Energy Forum in October 2009, Secretary of the Navy Ray Mabus committed "the Navy and Marine Corps to meet bold, ambitious goals" focused around key themes tied to energy: security, efficiency, and environmental stewardship.

The five energy targets include:

- Considering the lifetime energy cost of a system when awarding contracts during the acquisition process.
- Deploying a "Green Strike Group" fleet of nuclear vessels and ships powered by biofuels by 2016.
- Phasing in hybrid fuel and electric vehicles in its commercial vehicle fleet to reduce petroleum use by 50 percent.
- Using renewable sources of energy (such as solar, wind and ocean) to provide 50 percent of the shore-based energy requirements.
- Ensuring 40 percent of the Navy's total energy consumption comes from alternative sources by 2020.

The Department of the Navy [the second largest fuel user in the Department of Defense (DoD)] uses almost a third of the total DoD petroleum consumption at about 100,000 barrels per day. Seeking quieter and more efficient sources of energy, the Office of Naval Research (ONR) is leading the research efforts for alternative fuels and has been a key supporter of fuel cells for 20 years. Fuel cells have the ability to deliver clean and efficient power for Naval and DoD applications.

Fuel Cell Design

While batteries chemically store electrical energy in a closed system, a fuel cell reacts fuel with an oxidizer in the presence of an electrolyte (a substance designed to allow ion flow but prevent electron flow) and electrochemically converts it into electrical current. By maintaining the flow of reactant and oxidizer, fuel cells can continuously output electric current.

A hydrogen fuel cell reacts hydrogen with oxygen (usually from air), but many other combinations of fuels and oxidants are possible. Many designs exist for fuel cells but they all consist of an anode, electrolyte, and cathode. Hydrogen is catalyzed at the anode to become a positive ion and a free electron. The electrolyte carries the ion to the anode while the electrons travel through an external wire generating an electric current. At the cathode, the ion and electron are reunited and react with oxygen to form water.

One of the more common types of fuel cell is the polymer electrolyte membrane or proton exchange membrane (PEM) fuel cell (Figure 3-1). The electrolyte membrane in the PEM fuel cell is like a moist, thin piece of plastic wrap that allows charged ions (protons) to pass through. A typical PEM fuel cell produces approximately 0.6V and can be combined in parallel and series circuits (a fuel cell stack) to provide higher currents and higher voltages, respectively. Increasing the surface area of the cell can also produce higher currents from each cell.

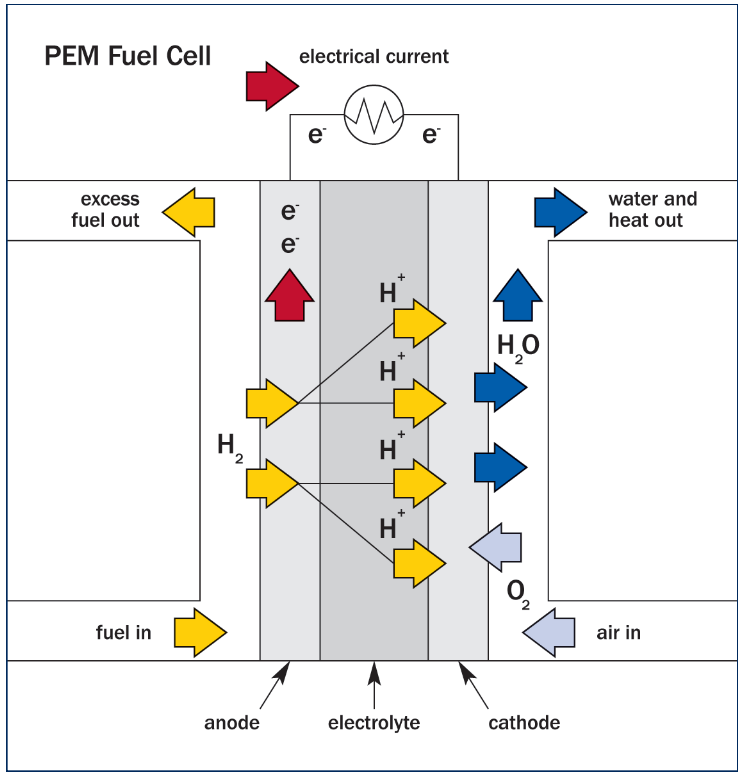


Figure 3-1: Schematic of a hydrogen polymer electrolyte membrane (PEM) fuel cell.[1] The basic parts are the fuel (hydrogen), electrolyte (defines the fuel cell type — polymer membrane in this case), the anode catalyst (typically platinum), and the cathode catalyst (often nickel).

Fuel Cell Controller

As the current increases the voltage decreases due to activation loss, ohmic loss (resistance of the cell components and interconnects), and depletion of reactants at catalyst sites. So it is necessary to control the system to operate in conditions which match up with the fuel cell maximum power point (MPP). In order to operate efficiently, electronics must be designed to carefully control several factors.

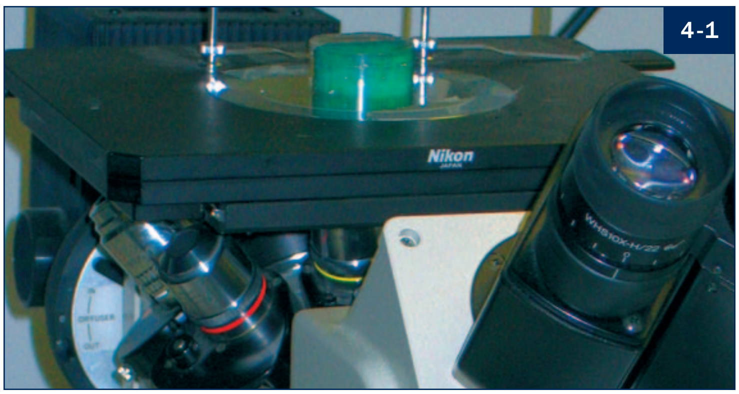
- Use the fuel cell at maximum efficiency by drawing current at a constant value.
- Determine the fuel cell MPP in "real-time."
- Control the flow of water, oxygen, and hydrogen into and out of the fuel cell.
- Control the charging and discharging of the auxiliary battery by monitoring the output voltage.
- Provide the power level as required by the load.
- Maintain the cell temperature.

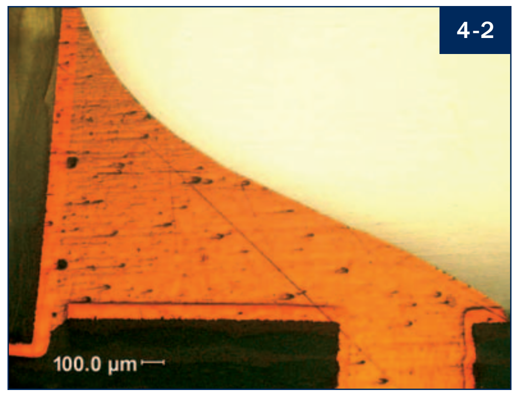
continued on page 9

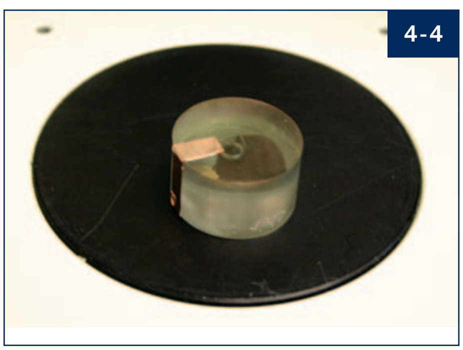
Tech Tips: Microscopy in Failure Analysis

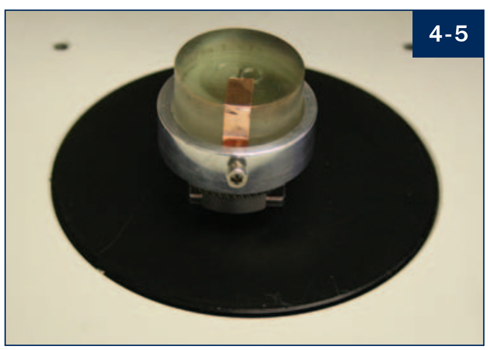
Both optical and scanning electron microscopy (SEM) are powerful tools for failure analysis in electronics and are used for low and high magnification examination. This article will provide detailed, step by step information for examining solder joints.

Before using the high magnification of the SEM, a traditional optical microscope or an inverted optical microscope is used to locate your area of interest. For most external inspections, optical microscopes are useful to locate any obvious defects or anomalies on boards and components. For internal inspections, the sample can be cross-sectioned (or “micro-sectioned”) to reveal layer by layer structure of a component on a printed wiring board (outlined in a previous Tech Tips article — *Empfasis*, April 2008). The optical image provides a road map for navigating your sample in the SEM.









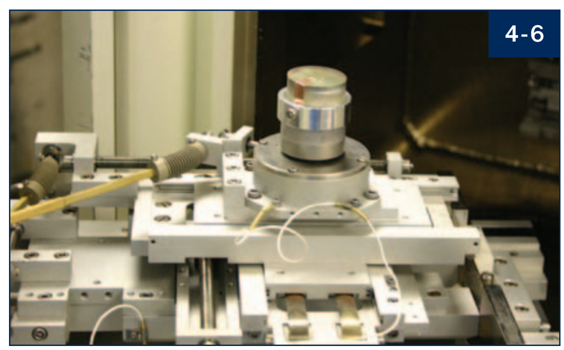


Figure 4-1: Epoxy mounted solder joint cross-section on inverted microscope. Figure 4-2: Optical image of epoxy mounted solder joint cross-section. Figure 4-3: Sputter coating of epoxy mounted solder joint cross-section. Figure 4-4: Copper adhesive tape on epoxy mounted solder joint cross-section. Figure 4-5: Sample holder with securing screw aligned with the copper adhesive tape for grounding. Figure 4-6: Sample mounted on stage holder in SEM sample chamber.

Step 1: Using an inverted optical microscope, examine the cross-section of the sample. Place the sample face-down on the stage (Figure 4-1). Use the x and y-axes controllers to move your area of interest to the center of the optical field (Figure 4-2).

Step 2: To examine under a scanning electron microscope, samples must be made conductive. A sputter coater is used to deposit a thin conductive layer of gold on non-conductive samples (Figure 4-3).

Step 3: After sputter coating, a conductive copper adhesive tape is used to bleed off any electron charge that may build up on the sample surface. Notice the metallic reflection from the surface that has been sputter coated with gold (Figure 4-4).

Step 4: Place the sample in holder and secure with screw. Align the screw with the copper adhesive tape for grounding purposes (Figure 4-5).

Step 5: Secure the holder on the stage of the SEM sample chamber and center the stage (Figure 4-6). Evacuate the sample chamber and wait until it reaches the required high vacuum level.

Besides providing a greater magnification, a scanning electron microscope can be used to obtain elemental information from the sample. Backscattered electrons can be used to detect different chemical compositions in the sample. Heavier elements (higher atomic number) in the sample are able to backscatter electrons more than lighter elements and appear brighter in the image. In addition, characteristic X-rays are emitted when the electron beam interacts with the sample (energy dispersive X-ray spectroscopy or EDS). This provides information on elemental quantity and composition of the sample.

continued on page 11

Manufacturer's Corner: McDry

McDry storage boxes (Figure 5-1) prevent damage (Figure 5-2) to electronic components by reducing moisture absorption into the plastic packaging. The rapid expansion of absorbed water during a high temperature reflow process causes stresses that can damage the component. If the best way to solve a problem is to prevent its occurrence, storing components in an environment with controlled temperature and humidity is the easiest and least expensive decision to eliminate the moisture absorption problem.

Figure 5-1: McDry storage box.

Packages of many semiconductor components are made of materials that absorb moisture (hygroscopic). When the air-tight seal is broken on a shipping package, atmospheric water vapor will be slowly absorbed by the component material. During the high temperature reflow process in the oven, rapid heating causes the absorbed water vapor in the component to expand into a hot gas which can damage the package. This damage is not always visible but it often appears as small craters called "popcorning." Since the component is mounted on the circuit board, the easily seen top of the component could be free of visible damage, but the underside and inside of the component could be damaged and not visible. The easiest way to avoid this damage is to store the components in an environment where the humidity is controlled and held to very low levels.

McDry manufactures a line of metal storage boxes that routinely maintain a relative humidity of 5% and can offer storage down to 1%. Moisture is removed from the interior of the cabinet with a chemical desiccant system. When saturated, the desiccant is heated, releasing the trapped water through a vent to the outside of the cabinet. The vent then closes and the process repeats as needed. Recognizing that some customers and components demand almost zero humidity, the dry boxes are also available with a nitrogen purge. Flooding the cabinet with nitrogen drives out any moisture laden air much more quickly than the desiccant system (which can take as much as 15 minutes). This nitrogen purge can be exceptionally valuable when the door to the storage box is often opened and closed.

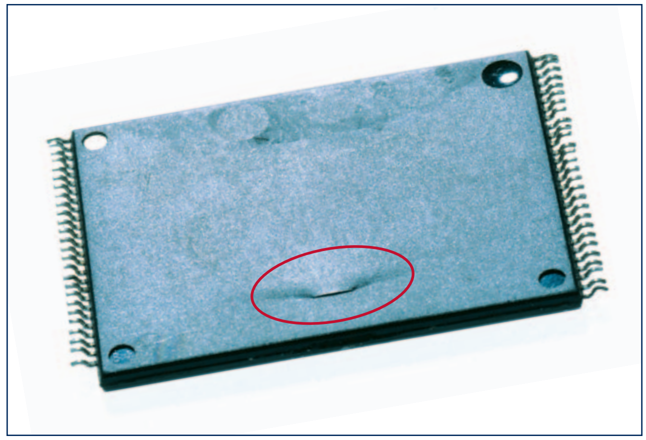


Figure 5-2: Damage to component (circled in red).

McDry storage cabinets conform to IPC/JEDEC J-STD-033B.1, "Handling, Packing, Shipping and Use of Moisture/Reflow Sensitive Surface Mount Devices." Since space is usually at a premium on the production floor, these low humidity storage boxes are available in a variety of sizes to fit the available space in the factory.

Recording the humidity is required in many applications to assure that the components have never been exposed to any moisture. The McDry storage boxes have an optional humidity recorder to provide records of humidity compliance.

In conclusion, a McDry storage box provides an industry standard of moisture protection for a very modest investment. Surface mount assembly equipment is expensive. Skilled labor to assemble and test the assemblies is expensive. The components are expensive. All this investment can be jeopardized if poor handling and storage practices lead to components that are damaged due to absorbed moisture. Storage boxes are a sound and sensible investment. For more information on the McDry storage box, please contact Mike Prestoy at mprestoy@aciusa.org.

Mike Prestoy | Senior Applications Engineer

Electronics Manufacturing Boot Camp Updates

Personnel must be trained to the most recent advancements in order to stay competitive in today's electronics manufacturing environment. The EMPF offers a variety of training and certification programs, including the Electronics Manufacturing Boot Camp. This course is focused on the fundamentals of manufacturing electronics products and electrical assemblies. Upon completion, the student will gain an understanding of the requirements used in the manufacture of assemblies from concept to finished product. The goal is to help the student make informed decisions to both establish sound manufacturing processes and modify current processes for new products or quality criteria.

Recently, the EMPF has enhanced the curriculum of the Electronics Manufacturing Boot Camp course. Many of the course's modules have been updated to include the industry's new technologies and techniques. Additionally, new practical elements have been added to give hands-on experience with commonly used manufacturing equipment in a realistic scenario that will reinforce the lecture material. While topics such as thermal profiling, component identification, and cleanliness testing remain relevant to the curriculum, there are several new modules that were added. This article will address three new modules that have been incorporated into the curriculum: Standards, BGA Rework, and Wire Bonding. Although the module on Standards is lecture only, the Wire Bonding and BGA Rework modules are supplemented with a hands-on lab so students can practice what they have learned in the lecture portion of the module.

Standards

Regardless of whether your company is manufacturing for military or civilian contracts, it has become common practice to build products to the quality level specified within a given industry standard. This module gives the student a basic understanding of which industry standards (e.g., JEDEC, ANSI, J-STD, EIA) best apply to the type of product being manufactured or procedure being

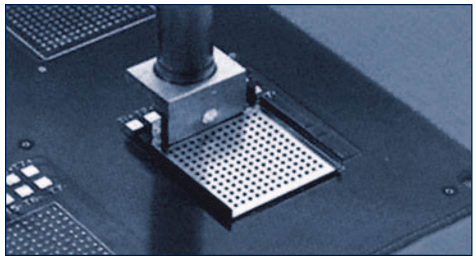


Figure 6-1: BGA Stencil Printer

employed within a manufacturing process. This lecture exposes the student to common industry terms and definitions which specify the class (level of quality) of a product, and describes how the determination of class is dependent upon the end use of the product. Additionally, this module contains a discussion of specifications that dictate criteria regarding components and parts used in electronics manufacturing (e.g., moisture sensitivity, ESD sensitivity).

BGA Rework

This module provides the student instructions on BGA removal equipment and techniques, reballing techniques, site preparation techniques, solder paste application methods (Figure 6-1), placement techniques (Figure 6-2) and criteria, as well as inspection and verification criteria.

Demonstrations of reflow and X-ray verification of BGA rework help reinforce the lecture portion of the module in a hands-on environment.

Wire Bonding

This module provides the student with an understanding of the basic principles of wire bonding. This includes the different types and sizes of wire bonds, a discussion on how wire bonds are formed, and methods for testing bond strengths. Throughout the lecture, focus is placed on the main characteristics and parameters of wire bonds, as well as the many

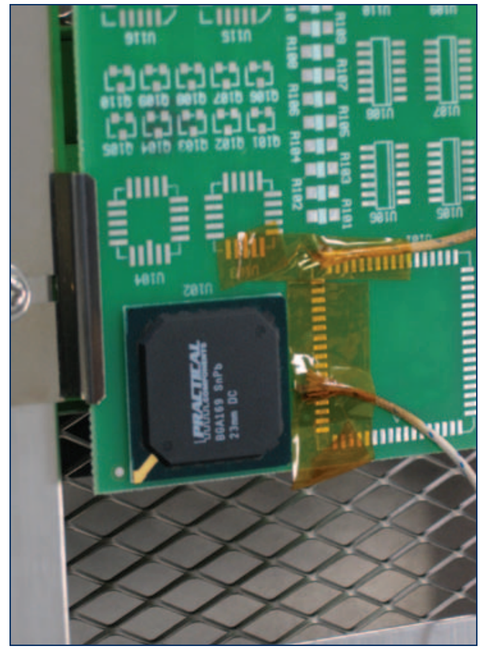


Figure 6-2: Thermocouple placed for temperature profiling for BGA placement.

different applications. During the lab portion of this module, wire bonding techniques and bond strength testing are demonstrated and practiced by the student.

These newer additions to this two-week course, along with the latest revisions of the other modules, provide a comprehensive overview of contemporary electronics manufacturing. Whether beginning a new product line or keeping up-to-date with the latest trends in the industry, the Electronics Manufacturing Boot Camp may be just the ticket for your manufacturing training needs. Our next scheduled Electronics Manufacturing Boot Camp is scheduled for September 13-17th (Boot Camp A) and September 20-24th (Boot Camp B). For further information, please contact the EMPF registrar at 610.362.1295 or via email at registrar@empf.org.

Ross Dillman | Technician/Instructor

Fuel Cell Manufacturing Challenges

(continued from page 1)

Barriers to reducing fuel cell costs include small volume production lines, no steady customer base, and the high cost of materials. For example, the cost of platinum (Pt) catalyst materials can contribute to half the proton exchange membrane (PEM) fuel cell cost. A steady customer base, especially a commercial customer, would stimulate the creation of high volume automated tooling and would reduce manufacturing cost per fuel cell.

Types of fuel cells that interest the Department of Defense (DoD) are PEM fuel cells, high temperature PEM (>160ºC) fuel cells, direct methanol PEM fuel cells (DMFC), reformed methanol PEM fuel cells (RMFC), and solid oxide fuel cells (SOFC). Table 1-2 lists the different types of fuels available and their associated challenges for use in DoD applications.

Hydrogen offers the greatest efficiencies for DoD applications, but production and distribution of hydrogen limits its use in military applications. Hydrogen carriers like methanol and ethanol offer advantages because liquids are easy to store, their theoretical mass energy density is high, and they can be reformed at the PEM operating temperatures. JP-8 and JP-5 are fuels with high hydrogen content and have the advantage of already being in the DoD supply chain. Fuel cells are sensitive to sulfur poisoning and JP-8 and JP-5 require sulfur removal and high temperature reforming.

PEM Fuel Cells

Low temperature (<100ºC) PEM fuel cells can be worn by a warfighter. The advantages of high temperature (>160ºC) over low temperature PEM fuel cells are greater fuel efficiencies, performance, water management, tolerance of contaminants, and kinetics of electrodic reactions. A barrier to expanding the commercial viability of PEM fuel cells is the high costs of Pt catalysts (which can contribute up to 50% of the total PEM fuel cell cost).[5] An additional barrier is the carbon monoxide poisoning of the Pt based cathodes. Pure hydrogen fuel allows for higher efficiency but

Applications	Power Range	Fuel Cell Technology	Fuel
Soldier Carried Power	1 - 100 W	DMFC	Methanol
		RMFC	Methanol and Water
		Small SOFC	Propane, Butane, Methane
		Chemical Hydride Fuel Cell	Sodium Borahydride, Ammonia Borane
Man-portable Power	100 W - 500 W	DMFC	Methanol
		RMFC	Methanol and Water
		Small SOFC	Propane, Butane, Methane
		Chemical Hydride Fuel Cell	Sodium Borahydride, Ammonia Borane
		Proton Exchange Membrane (PEM)	Hydrogen
		Standard SOFC	Propane, Butane, Methane
		Reformed PEM	JP-8, JP-5, Diesel
		Reformed SOFC	JP-8, JP-5, Diesel
Auxiliary Power Unit	500 W - 10 kW	Proton Exchange Membrane (PEM)	Hydrogen
		Standard SOFC	Propane, Butane, Methane
		Reformed PEM	JP-8, JP-5, Diesel
		Reformed SOFC	JP-8, JP-5, Diesel
Mobile Electric Power	1 kW - 100 kW	Proton Exchange Membrane (PEM)	Hydrogen
		Standard SOFC	Propane, Butane, Methane
		Reformed PEM	JP-8, JP-5, Diesel
		Reformed SOFC	JP-8, JP-5, Diesel
		Molten Carbonate Fuel Cell (MCFC) > 40 kW	Natural Gas, Coal
Large Stationary Power and Shipboard Power	> 100 kW	Standard SOFC	Propane, Butane, Methane
		Reformed PEM	JP-8, JP-5, Diesel
		Reformed SOFC	JP-8, JP-5, Diesel
		Molten Carbonate Fuel Cell (MCFC) > 40 kW	Natural Gas, Coal
		Phosphoric Acid Fuel Cell (PAFC)	Hydrogen, Natural Gas

Table 1-1: Fuel cell applications and power ranges.[1,3]

continued on page 8

Fuel Cell Manufacturing Challenges

(continued from page 7)

production, storage, and distribution of hydrogen is not as readily acceptable for defense applications as other fuels. Alcohols, such as methanol, are alternative fuels for PEM fuel cells. Liquids are easier to store than gases and the energy density of methanol is 10 times greater than compressed hydrogen and 15 times greater than lithium-ion batteries.

Solid Oxide Fuel Cells (SOFC)

The advantages of solid oxide fuel cells are their fuel flexibility. They can be run on a variety of hydrogen rich fuels, including logistics fuels (JP-8, JP-5) already in the supply chain. Their high operating temperature (>800ºC) allows for internal fuel reforming and decreases their sensitivity to sulfur poisoning. The high specific power density and ability to operate on sulfur containing military fuels make SOFCs especially viable for Naval applications.[6]

Fuel Type	Challenges for DoD Applications
JP-8, JP-5	Requires removal of sulfur; Requires reforming for fuel cells
Diesel	Aromatic hydrocarbon content
Gasoline	Flammable
Hydrogen	Low volumetric density; Tactal distribution issues
Methonal	Flammable; Toxic
Ethanol	Flammable; Requires reforming for fuel cells
Propane	Flammable; Requires high temperature fuel cell
Butanol	Relatively safe; Requires reforming
Biodiesel	Low sulfur content, but sulfur still needs to be removed; Requires high temperature fuel cell; Cold temperature start up issues

Table 1-2: Issues of various fuel types for DoD fuel cell applications.[1]

A Navy ManTech study is currently underway; it will focus on the affordability and manufacturability of fuel cells, particularly SOFC and PEM fuel cells. This effort will include documentation of the best practices, identification of manufacturing technology gaps and issues as well as the development of a roadmap to address those gaps and issues. Objectives also include the examination of methods to increase fuel cell producibility and decrease manufacturing costs for the commercial industry in areas applicable for Navy and other DoD applications.

References:

1 Hamlen, Robert, and Thomas Nycz. “Alternative Fuels for Military Portable Power.” *Power Sources Conference 2010*. US Army Research, Development and Engineering Command, 18 June 2010. Web. 22 July 2010. <https://www.powersourcesconference.com>.

2 De Jong, Marnie, Michael Dominick, J. J. Kowal, Jonathan Novoa, and Shailesh Shah. “Fuel Systems for Military Battery Charging Applications.” Proc. of the 44th Power Sources Conference, Las Vegas. 2010. 557-60. Print.

3 Department of Defense, and National Defense Industrial Association (NDIA) Manufacturing Division. POWER SOURCES TECHNOLOGY ROADMAP. Tech. no. #IMTI2010009. Oak Ridge: Integrated Manufacturing Technology Initiative (IMTI), 2009. Print.

4 Department of Energy. “Fuel Cells.” *Encyclopedia of Earth*. Cutler J. Cleveland, 19 Oct. 2006. Web. 22 July 2010. <http://www.eoearth.org/article/Fuel_cells>.

5 Adusumilli, Sumana, Javier Parondo, Sundara L. Ghatty, and B. Rambabu. “Carbon Supported Cathode Catalysts for PBI-based HT-PEMFCs.” Proc. of the 44th Power Sources Conference, Las Vegas. 2010. 365-68. Print.

6 Day, Michael J., and Scott L. Swartz. “NexTech’s FlexCell Planar SOFC Technology.” Proc. of the 44th Power Sources Conference, Las Vegas. 2010. 405-08. Print.

Rebecca Morris | Materials Engineer

IPC Revision E Training Available Now!

The new Revision E for both **IPC J-STD-001** and **IPC A-610** covers five years of critical upgrades, changes and clarifications. Both revisions were released in April 2010 and are covered in the training at ACI Technologies.

With the last update of the **J-STD-001** performed in February 2005, there are five years of significant changes to the standard.

Some of these changes are:

- Clarification on acceptable damage for stranded wire
- Requirements for heat shrinkable soldering devices
- Specifications for BGA underfill requirements
- Expanded treatment of rework acceptability

The **IPC A-610** is the most referenced electronic build standard in the world. Like the J-STD-001, it has been revised to incorporate the critical requirements for the assembly of quality circuit boards. Revision E has 165 new or updated illustrations, bringing the total illustrations to more than 800.

Some of the critical additions are:

- Expanded coverage for hot tear and lead free fillet lifting
- New trends and requirements in array technologies
- Enhanced package on package criteria

Contact the Registrar for scheduling by phone at **610.362.1295**, via email at **registrar@empf.org** or visit us online at **www.aciusa.org/courses**.

Ask the EMPF Helpline!

(continued from page 2)

The EMPF recommended that the customer further investigate the voiding observed on the 54-pin memory components. Two areas of attention are recommended: (1) the process used to assemble and solder the memory components and (2) the interface voids that were observed.

The interface voids should be investigated to determine if their location is actually on the interface. Cross-sectional analysis could be used to specifically examine a solder joint of interest and accurately determine the location of the void. This analysis would include evaluation of the PCB land for evidence of any contamination or metallurgical issues that would result in improper solder wetting.

The voiding level observed on the 54-pin memory should be reduced by adjusting the assembly process. One method is to test alternative solder pastes that may result in lower amounts of voiding in the resulting solder joints. Another method is to adjust the solder reflow profile to reduce the voiding present in the solder joints. Both methods can be used together or modifications to the reflow profile can be performed using the existing production solder paste.

The EMPF recommended cross-sectional analysis of the samples and X-ray analysis of future samples produced on a modified reflow process.

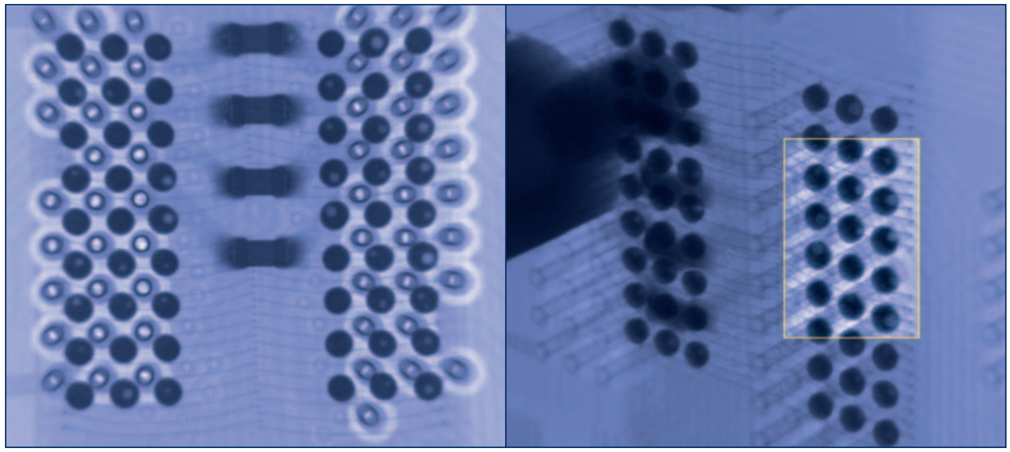


Figure 2-3: X-ray images of BGA voids in the smaller memory chip component; left is a view from above with significant voiding of the solder balls, right is an oblique angle view showing the voiding along the edges of the solder balls. Note the high contrast region (outlined in yellow) showing the difference between the dark and the lighter void areas.

The EMPF can assist with all aspects of board and assembly qualifications, inspections, and failure analysis to determine the root cause of solder joint failures. The EMPF can further assist with surface finish analysis, cleaning processes, and cleanliness testing for ionic and organic residues, as well as provide engineering services. Contact the EMPF Helpline at 610.362.1320 or visit us on the web at www.empf.org for more information.

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Optimizing Fuel Cell Performance

(continued from page 3)

A three stage converter can be used to provide this control (Figure 3-3).

The main component (first DC/DC converter stage) regulates the current drawn from the fuel cell regardless of the load (which leads to a fluctuating voltage on the DC bus). This stage is based on a boost converter switching-mode power supply (SMPS) containing two semiconductor switches (a diode and a transistor) and two energy storage elements (a bobbin and the output condenser) and provides a higher output voltage to the DC bus than the fuel cell input (Figure 3-4).

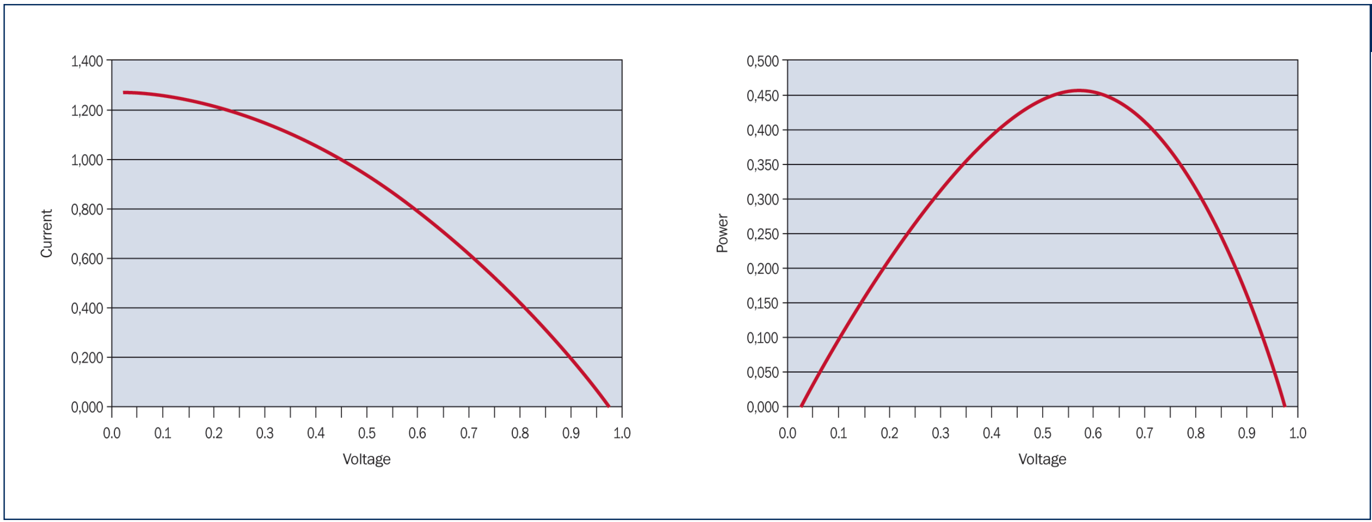
The bi-directional DC/DC converter (Figure 3-3) is used to keep the DC bus voltage within defined limits. When the bus voltage goes high the excess is directed to charge an auxiliary battery. When the bus voltage goes low the battery provides additional energy to maintain the DC bus voltage within limits. The inverter then converts the DC energy to whatever waveform the load requires.

Ion Tiger - Unmanned Aerial Vehicle (UAV)

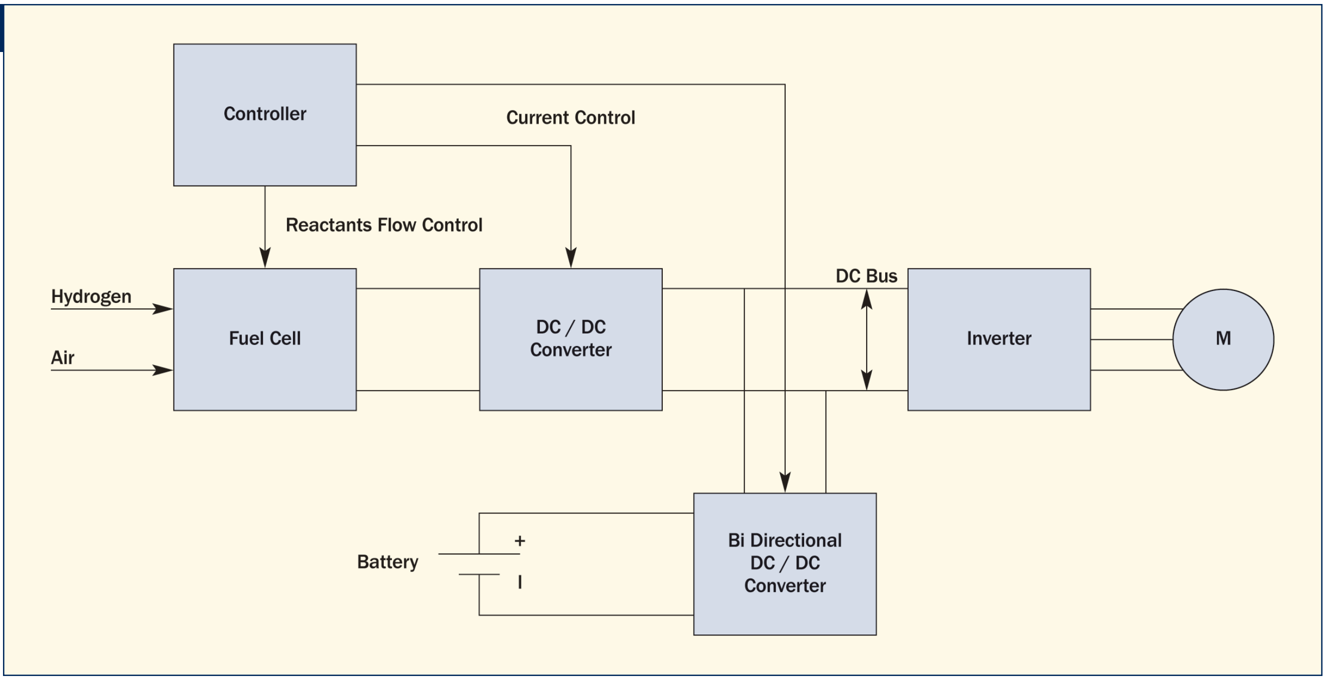
Significantly improved battlefield surveillance capabilities can be obtained by incorporating the hydrogen fuel cell into the Navy's unmanned aerial vehicle program. The Naval Research Laboratory (ONR's corporate laboratory) has demonstrated a reduced noise and heat

continued on page 10

3-2



3-3



3-4

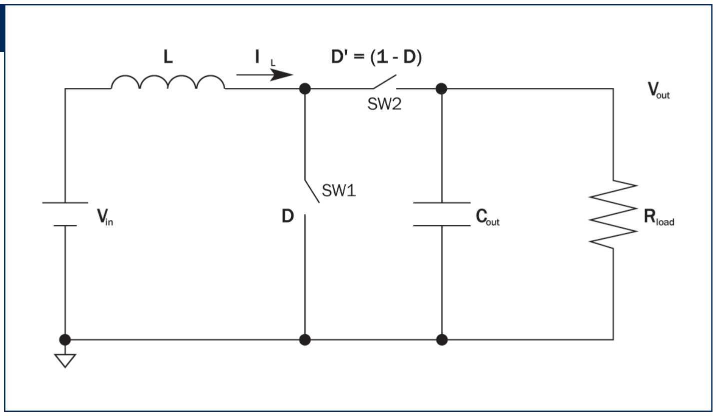


Figure 3-2: Characteristic voltage versus current (left) and voltage versus power (right) curves are shown for a small, 0.5W fuel cell.[2] The maximum power point (MPP) for this system is 0.455W at 0.827A.

Figure 3-3: Functional diagram of a fuel cell controller.[2]

Figure 3-4: Boost converter components.[2]

continued on page 11

Optimizing Fuel Cell Performance

(continued from page 10)

signature during test flights of their Ion Tiger UAV (Figure 3-5). The relatively small 550-watt fuel cells provide a greater range than earlier battery designs, give off no emissions, and allow the smaller UAV to lift heavier payloads.

Fuel cell power generation systems have the potential to provide the electrical power needs of future naval systems, as well as Marine Corps land-based and man portable system. Substantially reduced life cycle costs are expected as a result of greater system efficiencies, lower maintenance costs, and lower emissions when compared with other power generation systems.

Figure 3-5: Ion Tiger unmanned aerial vehicle (UAV).[3]

References:

1 "FCT Fuel Cells: Basics." *The Office of Energy Efficiency and Renewable Energy*. U.S. Department of Energy. Web. 23 June 2010. <http://www1.eere.energy.gov/hydrogenandfuelcells/fuelcells/basics.html>.

2 DONCA, Radu, Radu BALAN, Vistrian MATIES, and Olimpiu HANCU. "Control Method for the Improvement of the Efficiency of a Fuel Cell." Technical University of Cluj-Napoca, Romania. Web. <www.icrepq.com/icrepq-08/373-Donca.pdf>.

3 "ONR Fact Sheet: Ion Tiger - Office of Naval Research." Office of Naval Research. Web. 23 June 2010. <http://www.onr.navy.mil/en/Media-Center/Fact-Sheets/Ion-Tiger.aspx>.

Paul Bratt | Senior Packaging Engineer

Tech Tips: Microscopy in Failure Analysis

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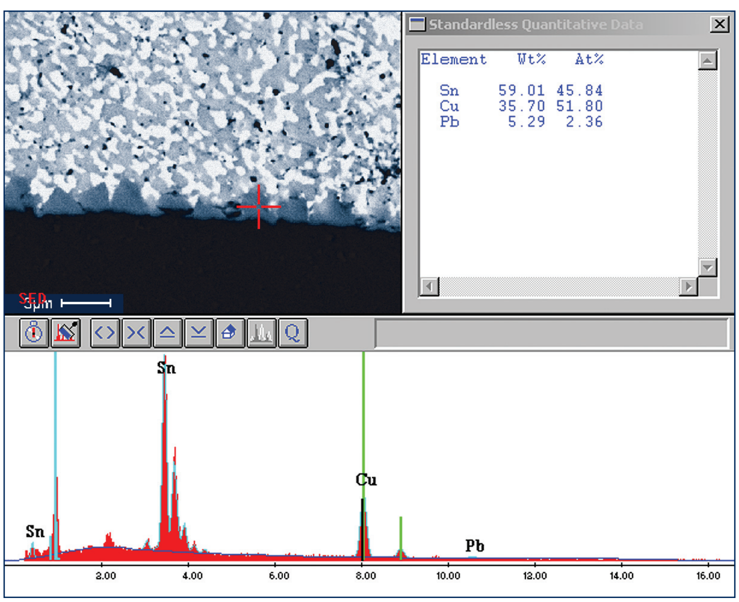

Figure 4-7: SEM image and EDS analysis of solder joint cross-section.

Step 6: After reaching high vacuum, open the valve between the electron gun and sample chamber. In this sample, a solder joint of eutectic tin-lead (Sn63-Pb37) is being examined. The tin phase appears gray and the lead phase appears white. The bottom black portion is the copper phase from the board surface mount pad. Dark gray denotes the tin-copper intermetallic layer. Using EDS, the chemical composition of the sample can be determined at a specific location (indicated by the red cross in Figure 4-7). In this sample, the intermetallic layer between the solder and the copper contains 59% tin, 36% copper, and 5% lead by weight.

The EMPF has the capability and experience to perform both optical and scanning electron microscopy for failure analysis. If you would like additional information, please contact the Helpline at 610.362.1320 or log onto the EMPF website at www.empf.org.

Phillip Yu | Senior Materials Engineer

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