Frequently Asked Questions and the Future of Failure Analysis

Failure Analysis has evolved in many companies to mean much more than analyzing a part from yesteryear and filing a report simply to satisfy a requirement. FA Engineers frequently interface with design, test, and product engineering and are an integral part of yield improvement. Many of you reading this will get a feeling of Déjà Vu for several of these common questions:

Q: After being presented the failure with minimal information…"How long will it take to do the analysis and how much will it cost?"

A: Break the analysis down in stages: First get the required electrical data such as linear vs. non linear IV leakage characteristics. Learn to rely heavily on IV data as it helps you decide the analysis path. Nonlinear effects imply photon emission, whereas linear effects imply thermal methods. Is the leakage temperature sensitive? Does the leakage exhibit 1/f noise or instability? Is the failure functional and sensitive to stimulus such as temperature or light? These preliminary data points are paramount to minimizing wasted time on the wrong $1M machines. By doing the analysis in stages and involving the requestor, an appreciation of what you do will develop.

Q: My part draws 10 mA so it will be easy to find the photon emission, right?

A: Recall Ohm's Law: V=I*R. There are several fundamental flaws with this question. Assumptions are being made that the site will be electroluminescent, that current alone converts to photons, the site is not obscured by metal and issues of current division through multiple sites can be ignored. Illustrated another way: 10 million transistors with 10nA of leakage = 100mA, yet with negligible photon emission! Magnetic imaging systems can map current via the right hand rule. Photon emission relates directly to the electroluminescent properties of the material being biased.

Q: My part draws 10 mA so it will be easy to find the hot spot, right?

A: As above, the same concepts apply to Ohm's Law and power density. Additionally, the distance of the defect under layers reduces the sensitivity dramatically. Predicting the result is anybody's guess.

Q: Why does it take so long, all you have to do is etch a few layers and take some pictures?

A: This question is made out of a simple lack of understanding and the person asking did not mean it as an insult. Get the requestor to assist with some "simple microprobing" for just 5 minutes on a practice part. Can you say "humble pie"? Frequent refreshers are necessary on different "simple tasks". You know progress is being made as the individual shifts to seeking your advice on future projects.

Q: Vendor B says their system can see 1pA of current, how much current can you detect on your system?

A: Unlike standard lab equipment, there is a great deal of fraudulent or misleading claims revolving around Photon Emission and Laser Induced Stimulus tools. Remember Ohm's Law above: V=I*R and that power = V^2/R. At least 2 knowns are required to solve this 3 variable equation. The statement of current drawn tells nothing about the needed IV relationship or the number of possible parallel leakage paths on the device. Run your part under your control on each system that you evaluate because vendors will do just about anything to sell you their tool. Sensitivity depends on resolution, wavelength, nature of the photon emitter, magnification, numeric aperture, integration time and lens throughput. Many of the claims for high numeric aperture macro lenses are misleading and based on a lack of understanding of the nature of photon emission coupled with a desire to make the sale. Many of you may have noticed the 20x .4 NIR objective is 2X less sensitive than the 5X .14NA with a forward biased emission, yet an avalanche emission site results in a 4X improvement. The 4X improvement is an understandable relation to NA performance, however, numeric aperture alone is inadequate to define performance! The 3D or volumetric nature of the emission source coupled with NA has a profound influence on sensitivity since NA also relates to depth of field collection from the source.

Q: Why do you want to build up a lab when you can use outside lab services and get data faster?

A: This question has some dynamics that need to be considered. Generally a small company cannot justify an internal lab. However, getting the basic tools such as a second hand curve tracer and probe station can be justified easily. All companies need to leverage external with internal lab capabilities. Running to an outside lab, mine included, and asking to blindly strip, look and take pictures is not a useful approach and I will do my best to talk you out of it. This question may also be an indicator of a corporate interest to dissolve your internal lab. Remedy: Agree to use outside lab services but not to baby-sit the outside project. The outside lab can be utilized through a product, design or test engineer. Parallel the analysis effort internally to convince management of the statistical soundness of multiple data points. If you are a reasonably good analyst, your familiarity with the problem, even with limited tools, will likely make you the internal hero of the company. Questions as to the soundness of relying totally on an outside resource and the cost overruns will likely begin to turn a potentially bad situation to your favor.

Q: What is it like to be a Consultant for other Companies?

A: I love it! The opportunity to network with FA Engineers and Managers in the work environment as well as at the Conferences is a great experience. Knowing that others have faith in my abilities to assist in solving problems which affect major commodity products is indeed rewarding. I don't consider myself a competitor with other labs in the SF Bay area since there is plenty of work to go around, and I have great relationships with multiple competing labs. These relationships work well since each lab has resources I may not have and vice versa. A fringe benefit of these relationships is an understanding of what the industry needs for new equipment, allowing me to improve my tools as well as sell them. Interestingly enough, I am my own worst competitor. Once I sell a tool to one of my customers they no longer need my consulting/lab services until the next generation requirement surfaces. There are some significant downsides to being a consultant, such as equipment costs and maintenance: This can be a major barrier to providing profitable FA lab services. Recouping the capital costs of an estimated 300K+ in lab equipment on top of paying yourself is a balancing act. The equipment is depreciating and soon your equipment will be obsolete if you rest on your laurels. Vacations are difficult to plan since the work load is unpredictable in the "Feast or Famine" mode. Keeping up with ever changing accounting policies to get paid can be frustrating at times but most of the frustration is alleviated by my customers at their respective companies.

Q: What will FA be like in the Future?

A: Failure Analysis or Product Enhancement, to use one of the euphemisms, was deemed to be extinct by the year 2000. This statement by a prominent guest lecturer about 10 years ago was based on the growing opinion the devices will be too complex, too small, and embedded to analyze. No consideration was given to the talent and eccentricity of the analytical community coupled with new tools and methods. Well, we are still here and I see no end in sight. The future of FA revolves around tools which leave the lab and interface to the test environment. Passive FA tools such as photon emission and thermal do face challenges as the geometries continue to shrink and the power densities wane. However, a new market for thermal based tools is growing in the package and board sector as these are also shrinking proportionately and becoming integrated circuits in their own right. Die analysis is becoming chip scale or multi-chip module based as the package becomes the die. It is inescapable that today's FA tools must interface not just mechanically but electrically to the tester and disturb the device synchronously with an external stimulus in order to map failures.

Established tools such as OBIC, OBIRCH, LIVA, TIVA, and XIVA [1,2] are useful tools that currently identify subtle defects through a form of laser stimulus. New tools such as Moiré thermal pattern imaging, Scintillation Liquid Crystal, Stabilized Fluorescence Microthermal Imaging, Soft Defect Localization (SDL) and Stimulus Induced Fault Test (SIFT) are emerging to meet the challenge [3,4,5]. These new tools all have capabilities to synchronize with the tester or directly control the event timing of the stimulus to the device. These tools are all blind search tools, meaning the scanner or sensor leads to localizing the defect with a minimal need to understanding the intimacies of the device design. In the past, it was acceptable to use the FA tool to sniff for the defect while the tester independently controlled the DUT. Device analysis requirements moving forward require vector control coupled directly to the analytical tool in order to localize the failure location. The challenge somewhat remains in making the tools work in harmony to this end goal since production testers are not necessarily designed with FA in mind. Although I have concentrated mainly on front end analytical tools, I would be remiss to not mention the importance of the AFM and AFP for defect characterization after localization[6]. The ability to map dopants, probe 65nm nodes, generate images similar to Passive Voltage Contrast, generate transistor IV curves without FIB pads and image defects, enables completion of the root cause analysis.

About the Author:

James Barry Colvin (Jim) comes from the Midwest holding Electrical Engineering Degrees from Purdue University. His childhood was spent breaking and repairing TV's and computers. He has 19 years of contributions to the Failure Analysis community through committee organizations for ISTFA, EOS/ESD, and IRPS and has published numerous award-winning papers on Failure Analysis techniques. Colvin has been working as a Consultant for over 12 years and originated the Passive Voltage Contrast technique, the first portable Emission Microscope, the Vibration coupler, and the laser illuminator, to name a few. Currently he is the CEO of FA Instruments, Inc. founded to provide leading edge tools for Failure Analysis. Jim currently holds 7 patents for products relating to the semiconductor field and is recognized as a contributor to the advancement of semiconductor technologies.

Feel free to contact the author at jim@fainstruments.com for more information.

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