

# Failure Analysis Laboratory

## 1 Electrical Failure Analysis (EFA) Laboratory

Prior to 1998 -- For the purpose of engineering debug and verification of the IC's electrical characteristic in the wafer and package levels, MOSAID 3490 with probe station, HP 4145 (semiconductor parameter analyzer) and oscilloscope were acquired. Early in 2000 -- In order to test high-speed and low power products in variable temperatures, MOSAID 4155 and thermal controller instrument were added.

## 2 Assembly Engineering and Chemical Laboratory

By the end of 1998 -- SAT (Scanning Acoustic Tomography), X-ray, package sawing machine, mechanical polishing machine, chemical hood, auto de-capping machine etc. were set up for the purpose of further quality improvement in packaging.

Early in 1999 -- Bonding wire defects, package delamination, die and passivation cracks, etc. could be detected by using these instruments and the information was quickly passed to the assembly house for improvement.

## 3 Physical Failure Analysis (PFA) Laboratory

Prior to 1999 -- PFA was performed mostly in the US based parent company, ISSI.

In 2000 -- Not only for engineering debugs but also for customer service, portable EMMI (Emission Microscope), FESEM (Field Emission Scanning Electron Microscope) equipped with EDS (Energy Dispersive Spectroscope), RIE (Reactive Ion Etching) and wire bonding system were set up sequentially to improve the PFA capability.

Early in 2001 -- ISSI FA laboratory became fully capable of performing FA works, from electrical analysis to physical failure analysis. Defects, such as gate oxide damage, via abnormality, metal damages, etc., induced during production line or field application can be detected. This FA capability helps reducing the cycle time from the product's development stage to its mature stage, improving the production yield and expediting the customer service.

# Failure Analysis Instruments

As ULSI integration is becoming more complicated, analytical techniques and instruments become more advanced and dedicated in dealing with process related problems. ISSI currently has owned all necessary analytical instruments as shown in Table 1 in assisting the solution search for process-related problems.

**Table 1 FA Instrument List**

Category	Instrument	Principle of operation	Applications
Electrical Failure Analysis Lab	<b>Emission Microscope (EMMI)</b>	Detection of visible light, near-IR light, which are emitted at the defect sites.	Light spot localization for device leakage.
	<b>Emission Microscope with InGaAs detector</b>	Detecting longer wavelength of near-IR light, which is emitted at the defect sites.	Light spot localization for device leakage.
	<b>Optical Beam Induced Resistance Change (OBIRCH)</b>	Defect identification by detecting the change of resistance at defect site with scanning of a laser beam.	Localization of leakage current path Detection of vias/contacts' high resistance
	<b>LC detection System</b>	Use of nematic liquid crystals for failure analysis.	Hot spot localization for device leakage.
	<b>Engineering MOSAID 3490</b>	Tester contains precision instrumentation combined with advanced pattern and timing facilities.	Providing functional AC and DC parametric testing capabilities.
	<b>Engineering MOSAID 4105,4155,4205</b>		
	<b>Parameter analyzer (Keithley 4200A) with Pulse Generator</b>	Applying a variable voltage, current or waveform sources to a device and acquiring the I-V curve.	Device's I-V (current-voltage) characterization.
	<b>Semi-Auto Probe Station</b>	Motor-driven probe station in conjunction with temperature controller for wafer.	Pad probing. Thermal stressing.
	<b>Manual Probe Station</b>	Probe station with anti-vibration system for wafer.	
	<b>Pico-Probe System</b>	Use of micro-needle for internal circuit probing of chip.	Internal circuit probing of device.
Assembly Engineering Lab	<b>Wire bonding System</b>	Using depressing force and ultrasonic vibration to make the Al wire bond for the metal pad of the chip.	Wire bonding for electrical analysis of device.
	<b>Oscilloscope</b>		Voltage waveform measurement.
Chemical Lab	<b>X-ray Radiography</b>	Image contrast based on the attenuation of an unfocused beam from a point source.	Inspection of the wire bonding, lead frame of packages.
	<b>Scanning Acoustic Tomographs (SAT)</b>	Observation of the internal interface by using ultrasonic waves.	Non-destructive analysis for package's interior.
Chemical Lab	<b>Reactive Ion Etching (RIE)</b>	Surface sputtering or etching of materials using accelerated ions of reactive gases.	To remove dielectric films such as $\text{Si}_x\text{N}_y$ and $\text{Si}_x\text{O}_y$ from devices.

<b>Category</b>	<b>Instrument</b>	<b>Principle of operation</b>	<b>Applications</b>
<b>Physical Failure Analysis Lab</b>	<b>Scanning Electron Microscope (SEM)</b>	Image from two dimensional intensity distributions of secondary electrons or back-scattering electrons from energetic e-beam.	Morphology observation. Micro structure analysis.
	<b>Energy Dispersive Spectroscopy (EDS)</b>	Attached to SEM equipment for detecting the radiation of characteristic X-ray.	Element detection. Composition analysis.
	<b>Optical Microscope (OM)</b>	Microscopy that magnifies images with a glass lens system.	For visual inspection of both wafer and package parts. A new microscope was moved in which can get wide depth of focus and do photo merge automatically.
	<b>Laser Cutting System</b>	Using laser beam with adjustable wavelength for material removal.	Quick and easy removal of various materials on device.
	<b>Sputtering Coater</b>	Thin film deposition by sputtering a gold/platinum foil.	SEM specimen coating for lowering surface charge effect.
	<b>Polisher</b>	Grinding with diamond paper.	Specimen preparation for cross-sectional and top-view observation.
<b>Out-sourcing Instrument</b>	<b>Transmission Electron Microscope (TEM)</b>	Microscopy that magnifies images using diffraction of transmitted electrons.	Structure analysis. Phase identification. Defect observation. Composition analysis.
	<b>Focus Ion Beam (FIB)</b>	Deposition or etching of the desired patterns onto the device surface using FIB.	Device circuit repairing. Precise cross-section specimen preparation.
	<b>Optical Beam Induced Resistance Change (OBIRCH)</b>	Defect identification by detecting the change of resistance at defect site with scanning of a laser beam.	Localization of leakage current path Detection of vias/contacts' high resistance
	<b>Conductive Atomic Force Microscope (C-AFM)</b>	Current sensing technique for electrical characterization of conductivity variations in resistive samples.	Detecting leakage or higher resistance of contact, junction etc.
	<b>3-Dimensional computed Tomography X-ray (3D CT X-ray)</b>	Image contrast based on the attenuation of an unfocused beam from a point source. A software program to build a volume by stacking the individual slices one on top of the other. The program may then display the volume in an alternative manner	Stereograph inspection of the wire bonding, lead frame, Sn ball or any interface of packages.
	<b>Nano-probing system</b>	Use of micro-needle for internal circuit probing of chip under SEM chamber and inspection.	Device internal circuit probing, measurement of transistor performance.
	<b>Thermal Wave</b>	Pinpointing failures by detecting heat emissions. The image detected by a high-sensitivity thermal emission detector (InSb detector).	Short-circuit of metal wires, Abnormality of contact holes, PKG short wires w/o de-capsulation, Oxide layer breakdown/leakage.

## Emission Microscope with InGaAs detector

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Emission microscope with InGaAs detector equipped with 5 lenses (0.8X ~100X) and having the capability of detecting visible light and near infrared light.



Figure 1

## Field Emission Scanning Electron Microscope

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Scanning electron microscope with electron gun of cold field emission and EDX system and having the resolution of 15 Å.



Figure 2

## Plasma Etcher (Reactive Ion Etching)

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Reactive ion etching system with two separated RF generators for isotropic or an-isotropic etching of silicon dioxide, silicon nitride and other materials using fluorine based gas.



Figure 3

## Engineering Wire-Bonding System

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Engineering Al wire-bonding system with auto-height detection and auto bonding function.



Figure 4

## Dual Wavelength Laser Cutter

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Laser cutter system with laser beams at two different wavelengths and with the function of single shot and continuous shots.



Figure 5

## Polishing System

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Polishing system with the function of bi-directional (clockwise and counterclockwise) rotation.



Figure 6