Product Overview

aixACCT Systems
Highest test flexibility due to modular concept of the TF Analyzer

System Solutions for piezoelectric material and device testing based on modular product concept

Assemble your own configuration!
TF Analyzer

- Hysteresis
- Pulse Test
- Small signal capacitance
- Fatigue
- Imprint
- Retention
- Leakage current
- Static Hysteresis
- Piezoelectric displacement
- Piezo-coefficient d33, e31
- Thermo
- Pyroelectric
- Manual Waveform
- Remote control
- Dynamic Leakage Current compensation
- In-situ compensation

aixPlorer

- Coupling coefficient
- Electromechanical hysteresis
- Pulse
- Memory window
- Browse data
- Wafer view
- Statistical evaluation (in case of database connection)

System Extensions

- Laser interferometer
- Temperature controller
- Force sensor
- Mech. preload system
- Probing station
- High voltage amplifier
- High power amplifier
- Switchbox
- Various sample holder
- Others on request

Applications

MEMS
- film bulk acoustic resonators, micro switches, membranes, printer, tilted mirror arrays

Actuators
- positioning systems, fuel injection systems, vibration damping

Memories
- ferroelectric memory, resistive memory, magnetic memory material
8 inch wafer Double Beam Laser Interferometer (aixDBLI)

As innovation leader for electrical thin film testing aixACCT Systems has extended the well approved double beam technique to the first commercially available Double Beam Laser Interferometer system for 8 inch wafer characterization. This semi-automatic system is used for piezoelectric and electrical reliability testing of MEMS (micro electro mechanical systems) devices on 8” wafers. The excellent resolution of this system with an repeatability accuracy better than 2 % distinguish this system for mass production qualification.

The aixDBLI system offers measurements of thin film thickness changes under electrical excitation with a proven accuracy (x-cut quartz) of 0.2 pm/V. The main feature of the system is the ultra fast acquisition time of a few seconds for a single measurement. Based on a new data acquisition algorithm, the measurement speed is enhanced by a factor of 100. This enables for the first time the comparison of electrical and mechanical data for thin films recorded at the same excitation frequency. Due to the differential measurement principle the influence of sample bending is eliminated, which is the major obstacle using atomic force microscopes (AFM) for these types of measurements.

Measurements:

- Electromechanical large signal strain and polarization and piezoelectric small signal coefficient and dielectric constant. From these values the coupling coefficient can be derived by using the additional aixPlorer software tool if the stiffness value is known.
- Fatigue and reliability of electric and electromechanical properties.
The unique properties of the aixDBLI system make it suitable in combination with a semi-automatic or automatic prober station for applications in production environments with high throughput requirements on 6'' and 8'' wafers. The whole set-up consists of optical components in a vibration damped chamber, the TF Analyzer 2000 and some additional analog circuitry. The system is operated and controlled by a Windows XP™ based measurement suite with linked programs for the TF Analyzer, for settings of the prober station and wafer positioning and contacting.

#### Accuracy and repeatability

1. Measurement of a x-cut quartz sample at different excitation voltages

![Graph](image)

2. Piezoelectric and dielectric coefficient measurement: 10 consecutive measurements at the same pad show a repeatability better than 2 %.
Sample Measurements

1. Polarization and Displacement

Large signal polarization and displacement measurement. PZT thin film sample response to large signal excitation voltage at room temperature.

2. Capacitance and Piezocoefficient

Small signal capacitance and piezocoefficient measurement. PZT thin film sample response to a DC bias voltage signal superposed by a small signal excitation voltage at room temperature.
## Technical Data

<table>
<thead>
<tr>
<th></th>
<th>Resolution</th>
<th>≤ 1 picometer tested by x-cut Quartz</th>
</tr>
</thead>
<tbody>
<tr>
<td>Measurement range</td>
<td>5 pm to +/- 25 nm</td>
<td></td>
</tr>
<tr>
<td>Wavelength</td>
<td>632.8 nm</td>
<td></td>
</tr>
<tr>
<td>Displacement/strain measurement</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>• 50 Hz - 5 kHz</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• 100 mV to 10 V</td>
<td></td>
</tr>
<tr>
<td></td>
<td>up to 200 V (optional)</td>
<td></td>
</tr>
</tbody>
</table>

### Piezoelectric $d_{33}$ coefficient

- **Bias voltage**
  - (1 mHz to 1 Hz)
  - 100 mV to 10 V
  - up to 200 V (optional)

- **Small signal**
  - (1 kHz to 10 kHz)
  - 100 mV to 10 V

### C(V) Measurement

- **Bias voltage**
  - (1 mHz to 1 Hz)
  - 100 mV to 10 V
  - up to 200 V (optional)

- **Small signal**
  - (1 kHz to 10 kHz)
  - 100 mV to 10 V
Piezoelectric thin film characterization system for MEMS

Electromechanical thin film properties are key characteristics for the design and layout of piezoelectric based micro-electromechanical system (MEMS) devices. Either the longitudinal piezoelectric coefficient \( d_{33} \) or the transversal piezoelectric coefficient \( e_{31} \) is used to realize the sensor or actuator functionality. The longitudinal coefficient can be measured with the aixDBLI system whereas the aixACCT 4-Point Bending (aix4PB) system is used for precise measurements of the effective transversal coefficient.

The aix4PB measurement system utilizes a modified 4-point bending set up, developed by aixACCT Systems in cooperation with the Swiss Laboratoire de Céramique (EPFL), which is especially adapted to piezoelectric thin film samples. This innovative set-up allows the application of homogeneous, well defined mechanical stresses to the thin film, which guarantees a precise extraction of the piezoelectric coefficient with well defined boundary conditions.

The standard aix4PB system consists of the 4-point bending sample holder, a TF Analyzer 2000, and a single beam laser vibrometer. It allows the following measurements:

- Full electrical characterization with polarization, capacitance, leakage current, and fatigue measurements like they are established in the TF Analyzer 2000 system.
- Measurement of the effective transversal piezoefficient by applying an alternating homogeneous mechanical strain to the sample and measuring the generated charge.
- All these measurements can be performed under additional compressive or tensile static loads too which allows to predict the piezoelectric film behaviour in the fully processed MEMS device.

The measurement set-up is displayed in principle in the figure below.

As an option the system is extendable with the aixACCT double beam laser interferometer for differential measurements of strain and piezoefficient \( d_{33} \), which eliminates the influence of sample bending effects.
Features / Specifications

- 4-point bending sample holder with
  - piezo actuator for force generation,
  - fixture for laser vibrometer, and
  - easy contact to top and bottom electrode of the sample
- All measurement capabilities of the TF Analyzer 2000 system including
  - Windows 2000 / XP operating system
  - Remote access and script control available as option
- Single Beam Laser Vibrometer with a minimum resolution of 1 nm

Detailed specifications and overall performance are strongly dependent on the integrated single components.

Sample Geometry

- The design of the bending samples typically looks like displayed below.

<table>
<thead>
<tr>
<th>Sample length</th>
<th>( l = 25 \text{ mm} )</th>
</tr>
</thead>
<tbody>
<tr>
<td>Length top electrode</td>
<td>( l_{TE} = 8 \text{ mm} )</td>
</tr>
<tr>
<td>Length top electrode contact</td>
<td>( l_{TE2} = 7 \text{ mm} )</td>
</tr>
<tr>
<td>Length top electrode (square)</td>
<td>( l_{TE3} = 1 \text{ mm} )</td>
</tr>
<tr>
<td>Length bottom electrode</td>
<td>( l_{BE} = 4 \text{ mm} )</td>
</tr>
<tr>
<td>Distance top electrode</td>
<td>( d = 8.5 \text{ mm} )</td>
</tr>
<tr>
<td>Sample width</td>
<td>( w = 3 \text{ mm} )</td>
</tr>
<tr>
<td>Width top electrode</td>
<td>( w_{TE} = 2 \text{ mm} )</td>
</tr>
<tr>
<td>Width top electrode (contact)</td>
<td>( w_{TE2} = 0.1 \text{ mm} )</td>
</tr>
</tbody>
</table>
Sample Measurements

- Large signal polarization measurement.

- Effective transversal piezoelectric measurements at different frequencies.


Supported by the European Commission through the 6th Framework Project "MEMS-pie", [www.sintef.no/memspie](http://www.sintef.no/memspie)
Piezoelectric Evaluation System (aixPES)

This system is used for comprehensive electrical and electro-mechanical characterization of piezoelectric bulk ceramic samples. Large and small signal material characteristics can be evaluated over a wide temperature range. The samples current response is measured by applying an electrical voltage excitation signal using the flexible and precise virtual ground method. The samples displacement is simultaneously measured with an laser interferometer system.

- **Application**
  - Material characterization for research and development
  - Device qualification
  - Large and small signal measurements
  - Temperature dependent measurements
  - Reliability and fatigue tests
  - Leakage current measurements

- **Highlights/Benefits**
  - One system for comprehensive evaluation of piezo- and ferroelectric bulk ceramic materials e.g. for sensor and actuator devices
  - One software for external hardware control (e.g. temperature controller, high voltage amplifier, displacement sensor, oscilloscope) and data acquisition
  - Remote access and script control available
  - Optional database connection (ODBC) for easy access on material / device characteristics
  - Adaption to customers' hardware and customer specific requirements
  - Update service
  - User support
Features

1. Supported hardware
   - Internal and external high voltage amplifier (+/- 100 V up to +/- 10 kV)
   - Sample holder for bulk ceramic samples
   - Temperature controller and temperature chambers
   - Displacement sensors (e.g. laser interferometer, capacitive, or inductive)
   - External lock-in or impedance bridge

2. Measurements
   - Large signal electric polarization and displacement (uni- & bipolar)
   - Small signal capacitance, loss tangent, and piezoefficient vs. uni- and bipolar DC bias voltage
   - Temperature dependent studies of electrical and electro-mechanical characteristics
   - Pyroelectric measurements
   - Leakage current measurements
   - Fatigue measurements
   - Impedance measurements
   - User defined excitation signals

3. Software
   - Windows 2000/XP operating system
   - Remote access and script control via GPIB or Ethernet
   - Database connection via ODBC interface
   - Measurement data export to ASCII
   - Measurement data exchange with aixPlorer software and Resonance Analyzer

Specifications

- All components of the aixPES set-up comply with part 15 of the FCC rules
- Detailed specifications and overall performance are strongly dependent on the integrated single components
Sample Measurements

- Large signal polarization and displacement measurement.

Soft PZT bulk sample response to large signal excitation voltage at room temperature.

- Small signal capacitance and piezoefficient measurement

Soft PZT bulk sample response to large signal excitation voltage at room temperature.
Temperature dependent measurement

Soft PZT bulk sample response to large signal excitation voltage and temperatures between 50°C to 200°C.
Ceramic Multilayer Actuator test bench (aixCMA) with temperature control

The aixCMA test bench for ceramic multilayer actuator characterization has been extended by a temperature control unit which allows now to perform all measurements in the temperature range from room temperature up to 200°C. This system has been developed by aixACCT Systems to fulfill customers requests for system solutions. It includes a unique sample holder for a wide range of different sized actuator devices, necessary amplifiers for excitation voltage and current response measurements, aixACCT’s advanced measurement software, and optional software tools for data analysis and data exchange with database management systems.

The aixCMA system offers comprehensive electrical and electro-mechanical characterization of ceramic multilayer actuator devices for device qualification and production control. Important actuator characteristics like blocking force diagram and actuator stiffness can be derived for a wide temperature range. Special user defined excitation waveforms for electrical and mechanical load allow investigations of the CMAs performance under real application conditions.

Application

- Blocking force and actuator stiffness measurements
- Large and small signal electrical and piezoelectric measurements
- Characterization of piezoelectric materials for energy harvesting devices
- Reliability and fatigue tests
- Impedance resonance measurements

Highlights/Benefits

- One system for comprehensive evaluation of piezo- and ferroelectric sensor and actuator devices
- One software for external hardware control (e.g. high voltage amplifier, laser displacement sensor, temperature controller, oscilloscope) and data acquisition
- Investigation of CMA under
aixCMA with temperature option

real application conditions (dynamic control of electrical and mechanical load, temperature from RT up to 200°C)

- Remote access and script control available
- Optional database connection (ODBC) for easy access on material / device characteristics
- Adaption to customers’ hardware and customer specific requirements
- Update service and user support

**Features**

1. **Supported hardware**
   - Internal and external high voltage amplifier (100 V up to 10 kV)
   - Sample holder for a wide range of multilayer actuators geometries
     - 5 mm - 50 mm actuator length
     - 2 mm - 15 mm actuator width and depth
     (other geometries on request)
   - Static and dynamic mechanical force load
   - Displacement sensors (e.g. laser interferometer, capacitive, or inductive)
   - Precise four point measurement
   - External lock-in or impedance bridge control

2. **Measurements**
   - Measurements under static and dynamic mechanical force load
   - Temperature dependent measurements from room temperature up to 200°C
   - Large signal electric polarization and displacement measurements (uni- & bipolar)
   - Small signal capacitance, loss tangent, and piezoefficient measurements vs. uni- and bipolar DC bias voltage
   - Leakage current measurements
   - Fatigue measurements
   - Impedance measurements with special low impedance measurement probe head (|Z_{min}| = 20 mΩ)
   - User defined excitation signals

3. **Software**
   - Windows 2000/XP operating system
   - Remote access and script control via GPIB or Ethernet
   - Database connection via ODBC interface
   - Measurement data export to ASCII
   - Measurement data exchange with aixPlorer software and Resonance Analyzer

**Specifications**

- All components of the aixCMA setup comply with part 15 of the FCC rules
- Detailed specifications and overall performance are strongly dependent on the integrated single components
Sample Measurements

- Blocking force diagram of a CMA at different excitation voltages and static preload

- Blocking force and CMA stiffness vs. excitation voltage
- Temperature dependency of blocking force and maximum displacement for a ceramic multilayer actuator 10 x 10 x 36 mm³

- Charge generation of a multilayer actuator at constant voltage and applied dynamic force excitation

- Impedance measurement of the length resonance of a 10x10x36 mm³ CMA with low impedance measurement probe head
TF Analyzer 2000 E Measurement System

The TF Analyzer 2000 E is the most sophisticated analyzer of electroceramic materials and devices. The test equipment is based on a modular idea, where four different probe heads can be connected to one and the same basic unit. Each of the four probe heads offers different characterization methods.

- Ferroelectric standard testing → FE module
- Magnetoresistive & ferroic material testing → MR module
- Relaxation current measurement → RX module
- Self discharge testing → DR module

By simply changing the module (probe head) you switch to a different test method.

The system can control and operate with additional external hardware equipment, such as temperature units, probing stations, high voltage amplifiers, laser interferometers etc. Communication via serial interface, IEEE interface, or Ethernet is supported. Several other aixACCT measurement (e.g. aixDLBI, aixPES or aixCMA) systems are based on the TF Analyzer 2000 E as a core component.

### Features

**FE module**

The FE module is available in different performance levels. The standard configuration offers a frequency range from 1 mHz to 5 kHz. A special high speed hardware configuration of Basic Unit and FE-Module offers a frequency range up to 1 MHz for high speed applications.

The ferroelectric test module TF Analyzer 2000 FE is designed to make various measurements on ferroelectric materials to determine its main electronic characteristics.

Standard features of the FE-Module are:

- Hysteresis measurement
- PUND measurement
- Fatigue measurement
- Retention measurement
- Static hysteresis measurement
- Imprint measurement
- Leakage current measurement

and optional

- C(V) measurement
• Piezo measurement
• Pyroelectric measurement
• Impedance measurement (only with the enhanced system configuration)

As further options, which are essentially for testing ultra thin films and for ultra small capacitors, aixACCT offers as unique features of the TF Analyzer 2000 series:

• In-situ Compensation, and
• Dynamic Leakage Current Compensation (see below)

→ MR module
This module allows the investigation of magnetoresistive and ferroic materials. Additional hardware components are required like they are described in the aixMR system documentation. The module supplies a constant current excitation and measures the voltage drop across the sample with a high accuracy four point measurement.

→ RX module
The relaxation module TF Analyzer 2000 RX is designed to investigate polarization and depolarization currents of dielectric and ferroelectric materials. This module uses the voltage step method with a six decade current amplifier, which allows measurements without changing the amplification range. It is especially designed to investigate the relaxation behavior and the leakage current of integrated capacitors.

→ DR module
Investigation of the self discharge behavior of dielectric materials: voltage pulse method with an electrometer amplifier offering 30 fF input capacitance.

The DRAM module TF Analyzer 2000 DR is designed to measure the self-discharge behaviour of charged integrated capacitors to test the suitability of the material for DRAM applications and to check the minimum pulse width of a write operation.

→ In-situ compensation
With small pad sizes, below approximately 10 µm squared capacitors the influence of the parasitic capacitance becomes increasingly important. For sub micrometer dimensions the compensation is essential in order to derive correct and precise results. The only way to measure these data correctly is with the aixACCT patented method of a compensation of the influence during the measurement. Using a numerical calculation to compensate this influence does not work, because the recording amplifier is already saturated by the contribution of the parasitic capacitor to the current response.

→ Dynamic Leakage Current Compensation
With ultra thin films the influence of leakage current becomes significant on the results of the hysteresis curve of the ferroelectric material. A compensation based on static leakage current measurements is not very accurate and is very time consuming. Therefore a method has been developed by aixACCT to eliminate the influence of the leakage current on the results of the hysteresis curve. Using hysteresis measurements, the influence of the leakage current can be eliminated and the remaining material property is received.
## Specifications

1. **Computer hard- and software:**
   - Celeron M processor ≥ 1.6 GHz
   - VGA graphical interface
   - USB port
   - CD / DVD writer
   - 80 GB hard disk or larger
   - 512 MB RAM
   - Operating system Windows XP
   - 16-bit resolution further increased by lock-in technology
   - 4 input channels
   - aixACCT’s sophisticated and highly flexible ferroelectric test software
   - Remote and script control (optional)

2. **Measurement Modules**

<table>
<thead>
<tr>
<th>FE module</th>
<th>MR module</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Driving unit:</strong></td>
<td><strong>The electrometer amplifier offers ultra high impedance for voltage measurement</strong></td>
</tr>
<tr>
<td>• Voltage range ±25 V (optional external amplifier up to 10.000 V)</td>
<td>1. voltage range 10 V, 500 mV, 5 mV at 16 bit resolution accuracy better 1%</td>
</tr>
<tr>
<td>• Output impedance 10 Ω</td>
<td>2. Current range: +/- 30 mA or 500 µA, resolution ca. 15 nA</td>
</tr>
<tr>
<td>• Maximum hysteresis excitation frequency (load dependent) &lt; 5 kHz (250 kHz / 1 MHz with advanced high speed system and probe head adapted to the sample)</td>
<td>3. Maximum resistance of device under test 1 MΩ</td>
</tr>
<tr>
<td>• Min. pulse width 2 µs (50 ns high speed)</td>
<td>4. Minimum resistance of device under test 10 mΩ</td>
</tr>
<tr>
<td>• Min. rise time 1 µs (10 ns high speed)</td>
<td><strong>I/V measurement</strong></td>
</tr>
<tr>
<td>• Maximum capacitive load (freq. dependent) 1 nF</td>
<td>• current sine wave, measurement time: 10 ms to 5 s</td>
</tr>
<tr>
<td>• Maximum output current ±1 A</td>
<td>• Voltage compliance range +/- 10 V</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th><strong>Current amplifier:</strong></th>
<th><strong>Fatigue parameter:</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td>• Voltage virtual ground input</td>
<td>• Maximum frequency 300 kHz</td>
</tr>
<tr>
<td>• Current range 1 pA - 1 A</td>
<td>Test conditions: amplitude: 10 V peak to peak capacitive load: 1 nF</td>
</tr>
<tr>
<td>• High-voltage protection (optional)</td>
<td></td>
</tr>
<tr>
<td>RX module</td>
<td>DR module</td>
</tr>
<tr>
<td>-----------------------------------------------</td>
<td>-----------------------------------------------</td>
</tr>
<tr>
<td><strong>Voltage-step generator:</strong></td>
<td><strong>Voltage-pulse generator:</strong></td>
</tr>
<tr>
<td>• Max. amplitude ±10 V</td>
<td>• Maximum amplitude ±10 V</td>
</tr>
<tr>
<td>• Output resistance &lt; 5Ω</td>
<td>• Minimum pulse length 50 ns</td>
</tr>
<tr>
<td><strong>Current amplifier:</strong></td>
<td>• Maximum pulse length 640 µs</td>
</tr>
<tr>
<td>• Range 100 mA - 10 pA</td>
<td>• <strong>Switching properties:</strong></td>
</tr>
<tr>
<td>• Bandwidth (I &gt; 50 µA) 300 kHz, (I &gt; 1 mA) 500 kHz</td>
<td>• Turn-on delay time &lt; 2 ns</td>
</tr>
<tr>
<td></td>
<td>• $R_{on} &lt; 50 \Omega$</td>
</tr>
<tr>
<td></td>
<td>• $R_{off} &gt; 10^{13} \Omega$</td>
</tr>
<tr>
<td></td>
<td><strong>High impedance electrometer:</strong></td>
</tr>
<tr>
<td></td>
<td>• Input resistance $10^{13} \Omega$</td>
</tr>
<tr>
<td></td>
<td>• Input capacitance 30 fF</td>
</tr>
</tbody>
</table>
TF Analyzer 1000 Measurement System

The ferroelectric test system TF Analyzer 1000 is designed to allow various measurements on ferroelectric materials to determine its main electric characteristics.

Standard features of the TF Analyzer 1000 are

- Hysteresis measurement
- Fatigue measurement
- Retention measurement
- Imprint measurement
- Leakage current measurement

and optional

- C(V) measurement
- Piezo measurement

The TF Analyzer 1000 includes a built-in function generator, an analog input board, and a wide bandwidth virtual ground amplifier with driving unit. This system offers hysteresis measurements from 0.1 Hz to 1000 Hz bandwidth depending on the excitation voltage in virtual ground mode.

A Windows XP / 2000 based graphical user interface ensures easy access to all operations and has been designed to cover scientific and next generation application needs.
Features / Specifications

Computer hard- and software:

- IBM PC compatible computer
- VGA graphical interface
- USB port and 3.5” floppy drive
- 40 GB hard disk or larger
- min. 128 MB RAM
- Operating system Windows XP / 2000 or higher
- aixACCT’s sophisticated and highly flexible ferroelectric test software

Driving Unit:

- Voltage range ±12 V* (1% accuracy)
  (optional with external amplifier up to 10,000 V)
- Output impedance 50 Ω
- Maximum hysteresis excitation frequency (load dependent) 1000 Hz*
- Min. pulse width 20 μs*
- Maximum fatigue frequency 50 kHz*
- Slew rate (typical) 10 V/μs
- Maximum capacitive load (freq. dependent) 100 nF
- Steady state output current ±50 mA*

* Other options available upon request.

Current Amplifier:

- Virtual ground
- Current range 1 nA - 1 A (1% accuracy)
- High-voltage protection
- Rise time (maximum values)
  Ranges:
  1 nA  300 µs
  1 mA  30 µs
  1 A   10 µs

Dimensions:

- Height 100 mm, Width 480 mm, Depth 530 mm
- Weight 10 kg
Easy Check 300 Measurement System

The Easy Check 300 is your entrance card to electrical testing of ferroelectric materials.

This system offers the fundamental characterization features:

- Hysteresis measurement,
- Fatigue measurement and
- Leakage current measurement

in one test system. The measurements are performed automatically.

The Easy Check 300 includes a built-in function generator, a data acquisition board, and a high resolution virtual ground current amplifier with a low noise driving unit to guarantee accurate results. The EASY CHECK 300 comprises a built-in computer!

A Windows XP / 2000 based graphical user interface ensures easy access to all operations. The recorded data can be exported to data presentation programmes in ASCII format. Single measurements can be transferred into reports by cut and paste.

Examples of measurement results are given below.

Hysteresis recorded on BaTiO$_3$

Leakage current measurement on BaTiO$_3$
Features / Specifications

Computer hard- and software:

- IBM PC compatible computer
- VGA graphical interface
- USB port
- 40 GB hard disk or larger
- 128 MB RAM
- Operating system Windows XP / 2000
- aixACCT's sophisticated and highly flexible ferroelectric test software

Driving unit:

- Voltage range ±12 V; option ±125V (optional with external amplifier up to 10.000 V)
- Output impedance 50 Ω
- Maximum excitation frequency (load dependent) 250 Hz
- Maximum capacitive load (freq. dependent) 1 μF
- Steady state output current ±50 mA

Current amplifier:

- Virtual ground
- Current range 1 nA - 1 A

Dimensions:

- Height 100 mm, Width 480 mm, Depth 530 mm
- Weight 10 kg
Ferroelectric Random Access Memory Cell Tester

Memory window information based on analog hysteresis measurements on single cell capacitors after full integration process

Field of application

Production of FeRAM

- Quality control during production based on memory window information which is not influenced by deviation of CMOS process
- Single shot hysteresis data at MHz operation speed
- Classification of bit failure instead of bit failure identification

Highlights/Benefits

- Feedback for process optimization during production
- Time efficient testing in the MHz range
- Applicable to 2T-2C cell design and 1T-1C cell design
- Memory window information from analog test data
- Customized adaptation to available test environment
- Update service
- User support

Program features

Hysteresis, PUND tests and other test procedures can be run on a single cell.

Rise times down to 1 µs are available. Self designed pulse trains can be used to test various kinds of failure mechanisms. Pre-polarization pulse parameters can be set independently from the test sequence.

Test sequences with the same pulse train with varying amplitude at constant pulse width or with constant amplitude at varying pulse width can be performed using the Access Time software.

These tests are based on the patented In-situ compensation of the parasitic capacitance.

- Free update service for 18 months
- Individual updates
- Maintenance service
FeRAM Cell Tester

User support

We provide comprehensive and prompt support to our customers:

- Complete printed documentation, hotline help, on-site implementation
- Free technical support for 100 days
- Low cost annual maintenance service

Features

The FeRAM Cell Tester controls the BL, WL, PL of a full memory cell to record the hysteresis loop of a fully integrated memory cell. The FeRAM Cell Tester generates the required timing.

If the chip offers a layout change, the automatic acquisition of the material properties on a larger array can be done. In this case the FeRAM Cell Tester operates in conjunction with a switch box system and a probing station. The software of the FeRAM Cell Tester automatically adjusts parameter sets such as those for in-situ compensation etc.

Statistical evaluation is offered by the aixPlorer. E.g. the memory window of a single bit as well as the memory window distribution on a die or wafer can be derived. But any acquired parameter can be investigated with respect to statistics.

The major benefit of the FeRAM Cell Tester is the important information for process optimization in order to improve yield and therefore to reduce cost as well as reduce the time to market. The correlation of results of the digital and the analog tests offers essential new knowledge.

Specifications

The FeRAM Cell Tester comprises all functionality of high resolution measurements and speed down to the microsecond region.
**Sample Holder**

**Bulk Sample Holder**

Test fixture for high voltage measurements on bulk ceramic samples. The sample holder can be filled with silicon oil to prevent flashovers. For temperature dependent measurements the sample holder can be used inside a temperature chamber.

- **Features / Specifications**
  - Sample diameter 3 - 13 mm
  - Use of silicone oil possible to increase the flash-over voltage
  - Contacting of samples for current measurements with the virtual ground method
  - Maximum voltage up to 4000 Volt

**Piezo Sample Holder Unit**

Sample holder for piezoelectric bulk ceramic materials offer the simultaneous acquisition of electrical and electro-mechanical data over a wide range of temperature. The heating unit is integrated into the sample holder, so no additional temperature chamber is necessary. These investigations are essential for the development of actuator materials for most of the applications, e.g. fuel injection systems for car engines.

- **Features / Specifications**
  - Use of silicone oil possible to increase the flash-over voltage
  - Maximum voltage up to 5000 Volt (10 kV optional)
  - Contacting of samples for current measurements with the virtual ground method
  - Reliable and precise displacement measurements with commercial laser interferometer
  - Wide displacement working range and large distance to displacement measuring sensor in comparison to intensity based displacement sensors.
  - Temperature measurement located at the sample
  - Maximum temperature in oil 250°C
  - Sample thickness 0.1 - 4 mm
  - Sample diameter 5 - 25 mm
CMA/Bulk Sample Holder Unit

New sample holder unit for both Ceramic Multilayer Actuators (CMA) and piezoelectric bulk ceramic materials which offers the simultaneous acquisition of electrical and electro-mechanical data over a wide range of temperature. A heating and cooling temperature unit is integrated into the sample holder, so no additional temperature chamber is necessary.

Features / Specifications

- Maximum voltage up to +/- 5000 Volt
- Contacting of samples for current measurements with the virtual ground method
- Reliable and precise displacement measurements with commercial laser interferometer
- Wide displacement working range and large distance to displacement measuring sensor in comparison to intensity based displacement sensors.
- Temperature measurement located at the sample

- Temperature range from room temperature up to 200°C
- Sample thickness 0.1 - 20 mm
- Sample diameter 5 - 15 mm
The aixACCT High Voltage DC-stable power amplifier is designed to provide precise control of bipolar output voltages. It is available as a 200 V or 400 V output voltage. The 200 V version operates with an output voltage in the range of 0 to ±200 V DC or peak AC. The 400 V version operates in the range of 0 to ±400 V DC or peak AC. Applications for the High-Voltage Amplifier include AC and DC biasing for piezoelectric material characterization.

The High-Voltage Amplifier is configured as a non-inverting amplifier with a fixed gain of 40 V/V. Features include an all-solid-state design for a slew rate greater than 100 V/µs, a large signal bandwidth (-3dB) of DC to greater than 100 kHz. The active output stage sinks or sources current into small reactive or resistive loads throughout the output voltage range which is essential for achieving the accurate output responses and high slew rates demanded by reactive loads.

The voltage monitor provides low-voltage output signals for monitoring purposes. A Digital Enable feature provides a connection for a remote device to turn the high voltage on and off.

## Technical Data

200 V version, values in brackets for 400 V version (factory set)

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Specification</th>
</tr>
</thead>
<tbody>
<tr>
<td>Power supply</td>
<td>AC 110 / 220 / 240 V, 50/60 Hz ±10%, max. 110 W (factory set)</td>
</tr>
<tr>
<td>Fuse rating (2 pcs.)</td>
<td>500 mA T (slow blow) 220 / 240 V 5x20mm (1 A T for 110 V version)</td>
</tr>
<tr>
<td>Output voltage max.</td>
<td>± 200 V (± 400 V)</td>
</tr>
<tr>
<td>Output current max.</td>
<td>± 100 mA (min. ± 50 mA)</td>
</tr>
<tr>
<td>Output resistance (approx.)</td>
<td>100 Ω</td>
</tr>
<tr>
<td>Power bandwidth (-3 dB)</td>
<td>min. 100 kHz, small signal min. 200 kHz</td>
</tr>
<tr>
<td>Slew rate</td>
<td>min. 100 V/µs</td>
</tr>
<tr>
<td>Input voltage</td>
<td>± 5 V (± 10 V)</td>
</tr>
<tr>
<td>Input impedance</td>
<td>about 1 MΩ</td>
</tr>
<tr>
<td>Amplification</td>
<td>40 V/V ± 0.2 %</td>
</tr>
<tr>
<td>Voltage monitor output max.</td>
<td>± 5 V (± 10 V), 1/40th of output voltage at terminal ± 0.2 %, ± 5 mV, max. 5 mA</td>
</tr>
<tr>
<td>Disable input</td>
<td>open or high level → disable</td>
</tr>
<tr>
<td>Output impedance approx.</td>
<td>1 kΩ</td>
</tr>
<tr>
<td>Environment Conditions</td>
<td>0...40°C, RH 0..60 % non-con densing, max height 2000 m above sea level, indoor use only, pollution category 1</td>
</tr>
<tr>
<td>Dimensions (approx.)</td>
<td>W 30 cm/ L 30 cm /H 20 cm</td>
</tr>
<tr>
<td>Weight (approx.)</td>
<td>9 kg</td>
</tr>
</tbody>
</table>
aixPlorer Software Tool

Management and advanced analysis of measurement data for various thin and thick film and bulk applications.

![Image of aixPlorer software tool]

Fig.: Wafer distribution of impedance resonance measurements on different dies.

### Application

Extracting of additional characteristic values for FeRAM and sensors and actuators

- Parameter tracking for FeRAM applications, for example memory window parameter calculation of ferroelectric thin films
- Coefficient tracking for sensor and actuator applications, for example piezoelectric coupling coefficient or electro-mechanical hysteresis

### Performance

- Sophisticated assistance for users of aixACCT measurement systems
- Browsing of measurement data directories
- File content overview
- View measurement details for presentation and reports
- Multiple measurement comparison
- Optional database connection (ODBC) for easy access on material / device characteristics
Software Features

The aixPlorer software tool has been developed to assist users of the aixACCT measurement systems to manage and further analyze their measurement data. Users can browse through directories with measurement data and gain an overview of the file contents. Besides this, measurement details with measurement parameters and characteristic values can also be viewed. Sophisticated evaluation functions are available to extract additional characteristic values, e.g., the memory window parameter for FeRAM applications or the piezoelectric coupling coefficient for sensor/actuator applications. For power users with a large amount of measurement data the aixPlorer software can be optionally combined with a database program such as MySQL™ or MS Access™.

Features

1. Measurement data browser

- Windows Explorer-like tree view and selection of directories and aixACCT measurement files with name and timestamp
- Overviews of all records in a file with a small graph for each measurement
- Detailed view of single records including sample information, measurement conditions and characteristic values
- Multiple measurements can be opened in parallel to compare characteristic values, copy graph views for reports and presentations, and printing

2. Sensor & Actuator Applications: Extraction of additional characteristic values

Depending on the measurement type, different additional characteristic values can be extracted:

- Calculation of the bias voltage dependent coupling coefficient $k_{33}$ from small signal capacitance and piezoelectric coefficient $d_{33}$ measurement
- Extraction of coupling and piezoelectric coefficients from single resonance's in impedance measurements

- Extraction of the electro-mechanical hysteresis from unipolar displacement measurement
Rayleigh Analysis on hysteresis or displacement sub loops:

Summary of Rayleigh analysis with increasing excitation fields
3. FeRAM Application: Memory Window

- Extraction of memory window parameter from hysteresis measurements on ferroelectric thin films

4. Database connection (optional)

- Configuration of uniform database integration between hysteresis measurement software (for direct data export into the database), the aixPlorer software, and the database itself (MySQL)
- Export of the characteristic values of a whole file, single measurement tables, or of the additionally calculated characteristic values into the database
- Convenient selection of specified data from the database and visualization as statistical distribution
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