# Materials Lab


# Apps-XM series

AMETEK

solartron analytical

# Apps-XM series

- ***Smaller Footprint***
- ***Competitively Priced***
- ***Best In Class XM Accuracy***

**Materials Lab XM** is one of Solartron Analytical's Apps-XM series of **X**treme **M**easurement products that are each precisely focused on the requirements for specific applications.

These exciting new products have a much smaller footprint than most competitive units - delivering unmatched **XM** measurement performance while taking less of your restricted lab space.

Each **XM** module is individually calibrated using Solartron Analytical's unique multi-point calibration and tested to rigorous standards ensuring best accuracy.

| Apps-XM | |
|---|---|
| **EnergyLab XM** | for battery, fuel cells, supercapacitors |
| **EchemLab XM** | for corrosion/coatings and physical electrochemistry |
| **SolarLab XM** | for solar/PV cells |
| **Materials Lab XM** | for dielectrics, insulators, and electronic materials |


- ***Highest accuracy DC (IV, fast pulse) and EIS (C-V, impedance, Mott-Schottky)***
- ***Instant switching between DC and EIS - without changing sample connections***
- ***Low frequency to 10 µHz for degradation, trap state and material purity studies***
- ***Multiple AC techniques include single sine, harmonic analysis (non-linear materials), multisine for faster low frequency tests***

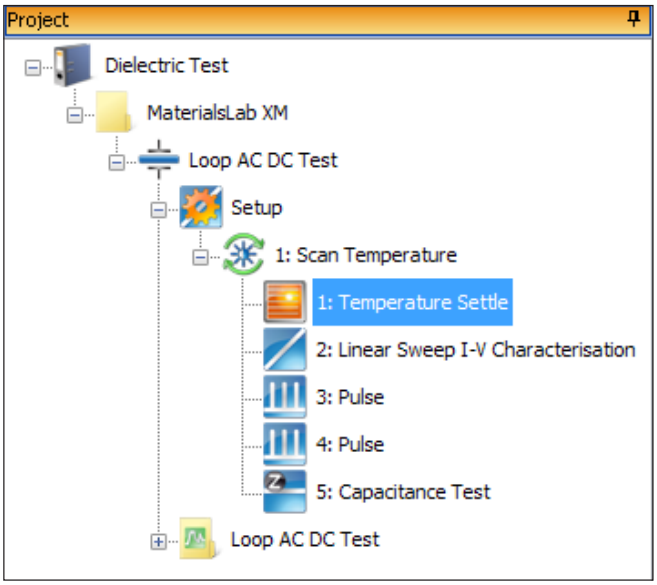
# Materials Lab XM

## Xtreme Measurement

**Materials Lab XM** is an application specific **XM** (**X**treme **M**easurement) product that is primarily focused on materials research.

The **Materials Lab XM** product provides a fully integrated reference grade time domain and AC measurement platform. No need to switch sample connections between techniques. Time domain measurements include I-V (current voltage) characterization as well as fast pulse techniques. AC testing techniques include everything from single-sine analysis, to multisine / Fast Fourier Transform for faster low frequency analysis, to harmonics and intermodulation for testing linearity and breakdown of materials. Measurements of electrical impedance spectroscopy (EIS), admittance, permittivity and capacitance are all provided from the **XM-studio MTS** software platform, together with integrated equivalent circuit analysis functionality.

Time domain and AC tests can be combined in test sequences and instantly switched, allowing DC and pulse waveforms to activate charge carriers, followed immediately by EIS analysis of the activated carriers. This closely linked integration is only with the **Materials Lab XM**.




Synchronized measurements from optical, mechanical displacement or other types of transducers can also be integrated via **Materials Lab XM**'s auxiliary measurement port, further expanding the range of measurements that can be included.

Temperature testing is also fully integrated with **XM-studio MTS** software providing control of a range of temperature controllers that can be combined with cryostats and high temperature furnace systems. Furnaces and high temperature sample holders provide the functionality to test solid oxide / ionic conductor materials over a range of temperature up to 1200 °C. Cryostats are often used to lower the sample time-constants into the frequency range that can be measured by the equipment, or to investigate low temperature phenomena such as carrier trap states.

The **Materials Lab XM** system provides complete integration of time domain I-V, pulse, EIS and temperature control for the complete characterization of materials.

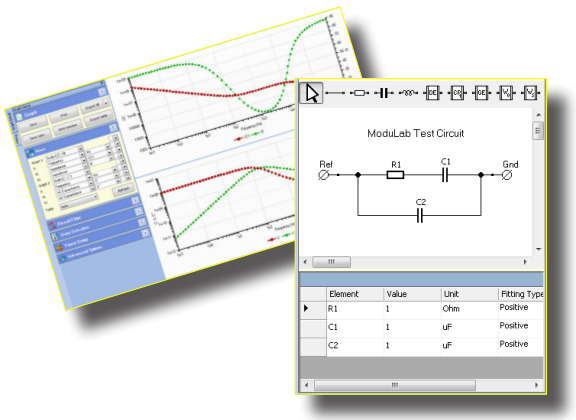
Materials Lab XM

Xtreme Measurement


## Time Domain

Materials Lab XM makes use of latest generation high-technology hardware for accurate waveform generation and data acquisition.

- Fast auto-sequencing of I-V, ramp, P-E and high-speed pulse techniques without switching cables
- MaterialsLab XM provides smooth analog voltage ramp waveforms essential for many research applications
- Selectable high-speed data acquisition up to 1 MS/s available for all measurement techniques including pulse and fast I-V




Dielectric Sample

## EIS Capability

Materials Lab XM utilizes one of the most versatile Frequency Response Analyzers available today and is able to auto-sequence time domain and AC measurements without switching cables.

**Single Sine Analysis**

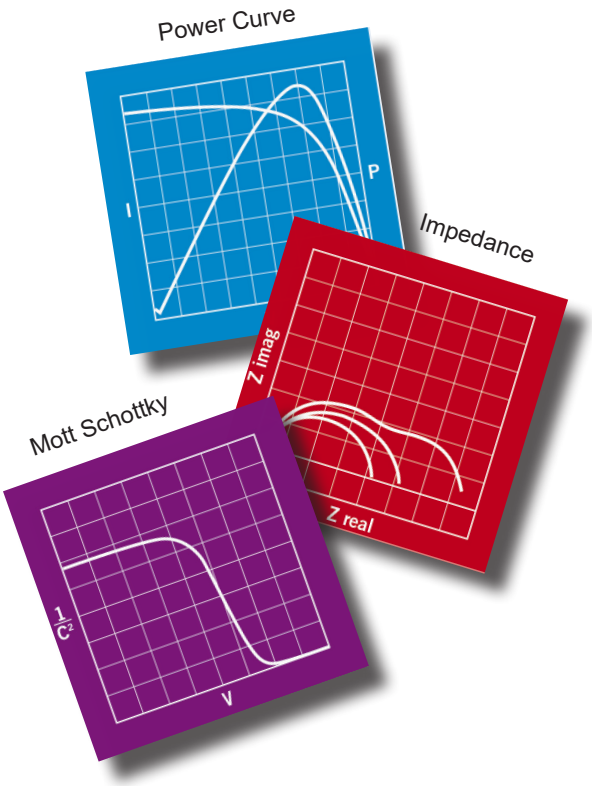
- AC tests include impedance, capacitance, and C-V/Mott-Schottky (with stepped or smoothly ramped DC)
- Ultra-high frequency resolution for resonant materials characterization

**Multi-sine / Fast Fourier Transform (FFT) Analysis**

- AC tests include impedance, capacitance, and C-V/Mott-Schottky (with stepped or smoothly ramped DC)
- Faster measurements across the whole frequency range saves test time and minimizes errors for time-variant materials

**Harmonic / Intermodulation Analysis**

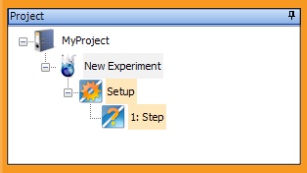
- To investigate sample linearity and breakdown



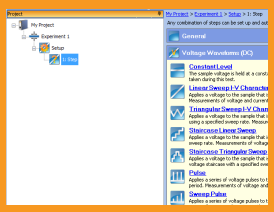
# xm-studio *software easy as 1... 2... 3... 4...*

**XM-studio MTS** software provides powerful automatic sequencing of time domain and AC techniques with a wide range of data analysis facilities including Fill Factor, and equivalent circuit fitting functions. From test setup, to experiment execution, to data analysis and final report; the software provides ready built templates to get you started. Tests can be setup and run with auto analysis of results in just a few clicks:

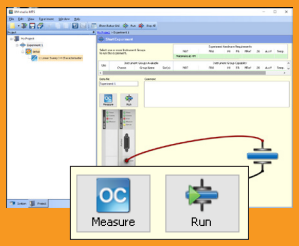
**1** Create new experiment



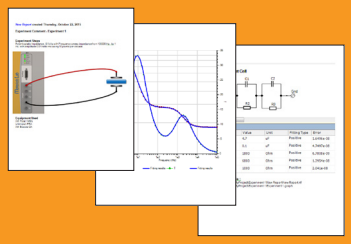

**2** Select Step type (Impedance in this case):

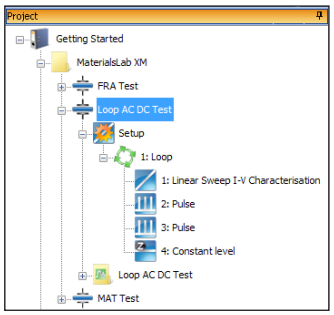


**3** Check your cell connections - match the diagram in the "Experiment" menu, and click "Run"



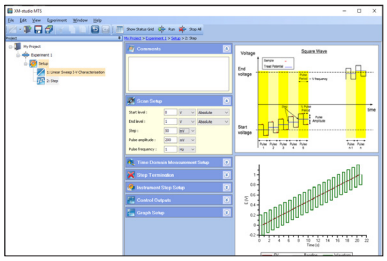

**4** Analyze the data using equivalent circuit fitting, and automatically generate reports using your favorite word processor software



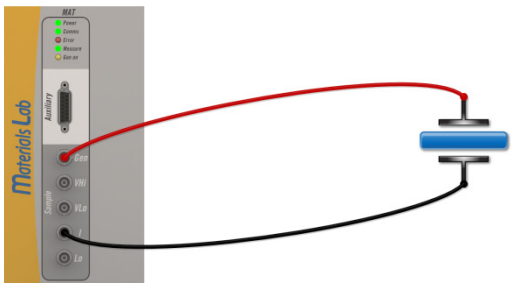



**XM-studio MTS** software is fully featured and graphically oriented for ease of use:

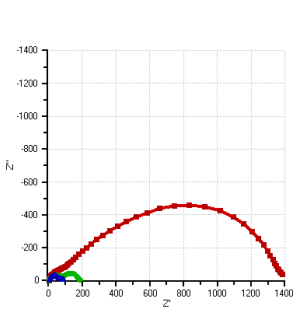
- Experiment sequences are setup using intuitive standard copy/paste, and drag/drop techniques.
- New experiments can be derived from previous experiments, by copying and then adjusting step parameters and test sequencing.

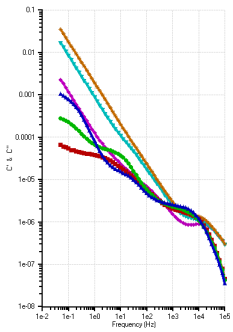


- Extensive use of graphical waveforms in the software enable full understanding of test parameters and experiment settings. The effect of parameter changes are seen real-time at setup, allowing setup errors to be identified and corrected before the test is run.




- **XM-studio MTS** software shows connection diagrams that ensure that your cell is correctly connected before the test starts.




- Equivalent circuit fitting is included, no need to export data
- R, C, L, Warburg constant phase elements, distributed elements...
- I-V Analysis

# *Accessories*

A wide range of accessories are available for use with the Materials Lab XM, including sample holders, cryostats, furnaces and amplifiers.

## Low Temperature Systems

- 5 K to 600 K (compatible with liquid helium and liquid nitrogen)
- Cryogen is supplied via a capillary tube that encircles the sample space ensuring low cryogen usage/low running cost
- Sample is located in a separate chamber containing an inert exchange gas (dry helium) which ensures that the sample is not affected by direct contact with cryogen vapor
- Custom sample holders for solid, powder or liquid samples

## High Temperature Systems

- For testing solid oxide, solid electrolyte, super-ionic conductors
- Samples tested from room temperature to 1200ºC
- Dual gas design for SOFC applications
- Split tube furnace for easy sample load

## Room Temperature Sample Holder

- Attachments for solid, powder and liquids
- Large range of sample sizes can be accommodated using interchangeable electrodes
- Guard ring to exclude errors due to fringing at edge of samples
- Integrated micrometer for permittivity calculations

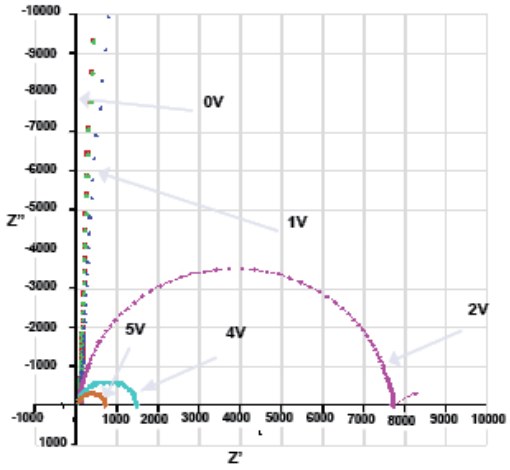
## Probe Stations

- Compatible with third party probe stations for semiconductor/electronic materials
- Provides accurate positioning of sample probes
- Can be combined with low temperature testing

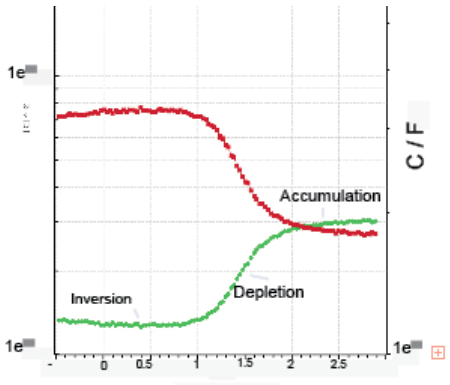
# Applications

## Organic Light Emitting Diode (OLED)

An OLED is a light emitting diode with an organic emissive electro-luminescent layer. These devices have attracted much interest from manufacturers of displays since they do not require backlighting which leads to thinner, lighter displays requiring much less power. However, much work still remains to improve the lifetime and stability of the organic materials. The electrical characterization of these materials not only serves to test the stability of the materials but is also used to understand the fundamental mechanisms and processes that contribute to the efficacy of these devices for their applications.




Cole-Cole (Nyquist) plot of the OLED operated under different DC bias voltages (as shown in the diagram)



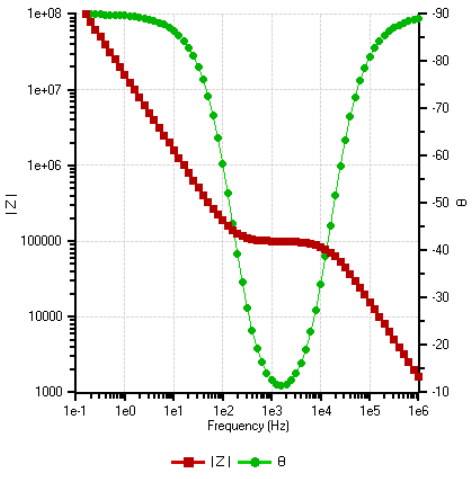

C-V and Mott-Schottky plots ($1/C^2$ vs V) of a 3N701 MOSFET. Stimulus frequency = 100 kHz, AC level = 10 mV

## Semiconductor

Semiconductor materials continue to receive much interest in the academic and industrial community as the requirements for more efficient devices and new applications arise. Electrical characterization offers a powerful, non-destructive means to determine many important properties of semiconductor materials and devices such as dopant density and dopant profiling, electron-hole recombination kinetics, identification of mobility carriers and oxide electrical integrity.

## Dielectric Materials

Dielectric materials are non-conductors of electricity (electrical insulators) that are able to be highly polarized by an electrical field (this is expressed as the material's dielectric constant). Charges within dielectric materials can be displaced from an equilibrium position by an electric field. On removal of the electric field, the material returns to its original state and the time taken to do this is referred to as the relaxation period. Typical tests involve applying a varying electrical field (AC waveform), and monitoring the relaxation of the material as a function of its permittivity (capacitance and conductance) vs. the applied AC frequency.



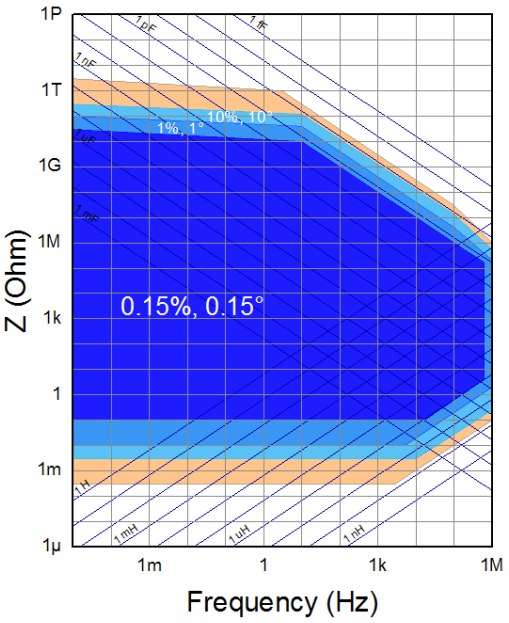

Materials Lab XM Xtreme Measurement

# Specifications

| Time Domain Analyzer | |
|---|---|
| Measurement mode | 2, or 4 terminal |
| Connections to sample | Gen, VHi, VLo, I |
| Sample connection cables | 4 x BNC-BNC (1 m) |
| Impedance measurement bandwidth | 1 MHz (via FRA) |
| Floating | yes |
| **Generator (Gen)** | |
| Smooth scan generator | 64 MS/s<br>interpolated and filtered |
| Maximum Voltage (open-circuit load)<br>DC + peak AC (subject to slew rate limit) | ±8 V |
| Maximum voltage resolution | 150 µV (<3 V)<br>400 µV (≥3 V) |
| Maximum output current | ±100 mA |
| Output impedance (nominal) | 50 Ω |
| Applied voltage error (open-circuit load) | ±0.2% setting<br>±800 µV (<3 V)<br>/ ±2 mV (≥3 V) |
| Voltage scan rate | 1.6 MV/s to 1 µV/s |
| Recommended maximum scan rate<br>(using 1 MS/s acquisition rate) | 25 kV/s |
| Minimum pulse duration | 1 µs |
| Maximum slew rate | >10 V/µs |
| **Voltage Measurement (VHi / VLo)** | |
| Maximum Voltage Measurement | ±8 V |
| Ranges | 8 V,<br>3 V to 3 mV in decades |
| Accuracy (reading % + range % + offset) | 0.1% + 0.05% + 100 µV |
| Maximum time domain sample rate | 1 MS/s |
| Maximum resolution | 1 µV |
| **Current Measurement (I)** | |
| Maximum current | ±100 mA |
| Ranges | 100 mA,<br>30mA to 30 nA in decades |
| Accuracy (reading % + range % + offset) | 0.1% + 0.05% + 100 pA |
| Maximum time domain sample rate | 1 MS/s |
| Maximum resolution | 1.5 pA |
| **Auxiliary Voltage Inputs** | |
| Number of auxiliary DC channels | Four |
| Specification | Same as VHi/VLo |
| Sychronized to VHi/VLo measurement | Yes |

| Frequency Response Analyzer | |
|---|---|
| Maximum sample rate | 40 MS/s |
| Frequency range | 10 µHz to 1 MHz |
| Frequency resolution | 1 in 65,000,000 |
| Frequency error | ±100 ppm |
| Minimum ∫ time per measurement<br>(single sine, FFT or harmonic) | 10 ms |
| **Signal Output** | |
| Waveform | Single sine, multi-sine |
| Single Sine | Linear / logarithmic |
| Multi-sine / harmonic frequencies | All or selected |
| **Analysis channels** | |
| Accuracy (ratio) | ±0.1%, ±0.1° |
| Anti-alias, digital filters, DC bias reject | Automatic |
| Analysis modes: | Single sine, FFT, harmonic |
| DC Bias rejection | Automatic |

## Impedance Accuracy




- 2T connections > 1 kΩ , 4T otherwise
- 4T connections < 1 Ω
- Faraday cage and suitable screening recommended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