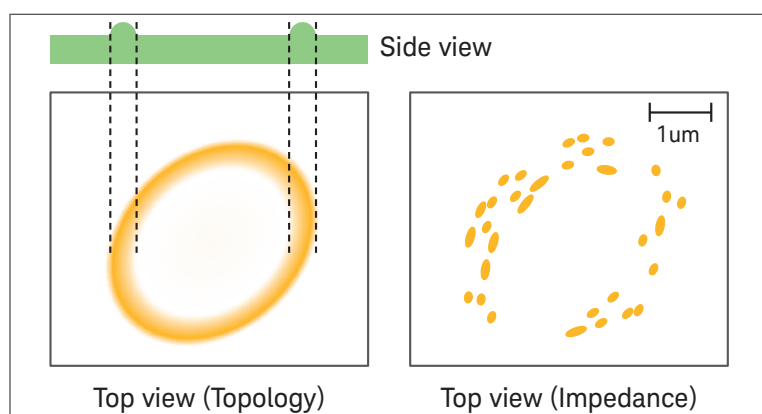


[Battery Material Evaluation]

Keysight-Unique

Impedance Distribution Measurement Using High Frequencies Enables Observation of Electrode Uniformity and Deterioration

New Electrode Observation Method Integrating an AFM (Atomic Force Microscope) and a VNA (Vector Network Analyzer)



Examples of observations for electrode evaluation from an AFM's SMM mode using high frequencies

"We want to evaluate actual electrodes using not only surface images but also the information beneath it!"

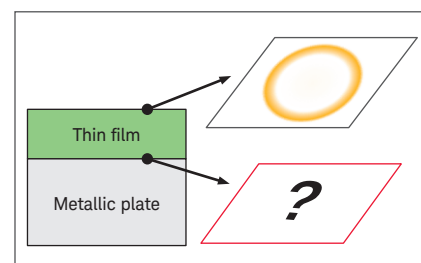
"We want to precisely understand the characteristics of a specific area in nano-order resolution!"

"We want to get information that conventional methods cannot provide!"

We'll never let you down!

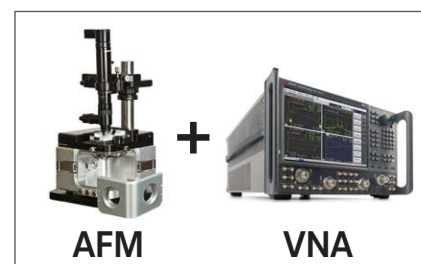
Check the surface as well as information underneath the surface

Searching for the cause of a non-uniformity in an electrode? If the target is a metal electrode filmed with another thin metal, understanding buried information such as data about thin film interfaces is also important. The SMM mode of an AFM helps you understand such buried information by measuring the uniformity of impedance distribution. Overlaying the buried information on the surface image may show you the cause of the problem.



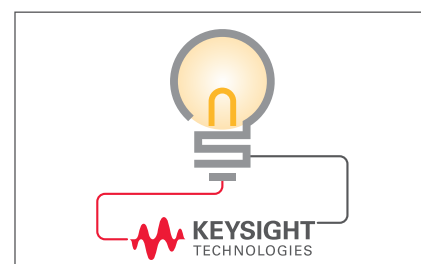
Accurately evaluate in situ characteristics of low-resistance materials

Although conventional SMMs using DC or low-frequency signals are good for evaluating semiconductors, it's impossible to evaluate the in situ characteristics of electrodes, which have little resistance and thus spread out the signals. To measure such low-resistance materials accurately, the signal needs to be high frequency, which makes the signal rather focused. Combining an AFM with a VNA that supports frequencies into the GHz range enables in situ characterization of electrodes.



Try Keysight's proprietary method to seek new insights

For engineers trying to open up a new field, developing new materials and structures means also seeking new evaluation methods. Only Keysight, the world's No. 1^{*1} vendor of network analyzers, can offer an SMM environment with a combination of an AFM and a VNA. This new SMM environment will give you an opportunity for new insights unlike other methods and products.



*1 : More than an 80% market share (annual world-wide shipment basis, according to Keysight)



Basic model 6500

Three AFM models are available to support SMM observation.
The 6500 has a chamber that is capable of environmental controls.



Standard model 9500

A chamber-type model with revolutionary new software and hardware.
Capable of high-speed scanning, high-speed multi-point force mapping, and more.



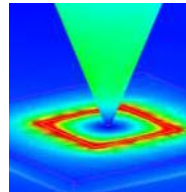
Large-stage model 5600LS

All the performance of the Keysight 6500 but on a platform with a large travel stage.
Suitable for observation of large samples.



Available to measure frequency characteristics up to 20 GHz

This VNA from the N52xxB PNA series accurately measures the frequency responses of specific areas even in low-resistance samples. You can also count on Keysight for signal calibration methods for observation systems.



Interpolate and quantify SMM data with electromagnetic analysis

The output from the FEM simulation in EMPro agrees well with that from SMM mode measurements,^{*2} and therefore the simulation can be used for the interpolation and quantitative explanation of measured data.

*2 : See also

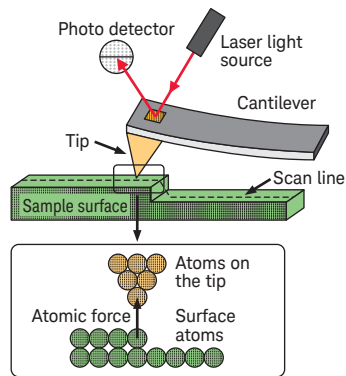
Application note "SMM EMPro"

<http://literature.cdn.keysight.com/litweb/pdf/5991-2907EN.pdf>

Application note "Scanning Microwave Microscopy Solutions for Quantitative Semiconductor Device Characterization"

<http://literature.cdn.keysight.com/litweb/pdf/5992-1659EN.pdf>

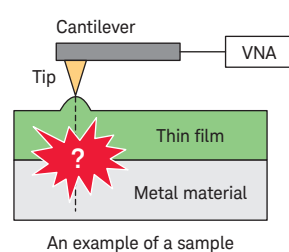
What is an AFM (Atomic Force Microscope)?



A kind of microscope that enables three-dimensional observation of the shape of a sample surface by optically detecting slight deflections of the cantilever caused by the ionic repulsive force from the sample surface.

Surface shape	Mechanical properties	Magnetic/thermal properties	Electrical properties
Height, unevenness, roughness, distribution	Viscoelasticity, capacity to adsorb, friction force, hardness distribution	Magnetic force, magnetic permeability, thermal conductivity	Current, potential, impedance, dielectric constant, conductance, electrochemical reactions

What is SMM (Scanning Microwave Microscopy)?



An examination method to obtain buried information from a sample by integrating microwave network analysis technologies and high-resolution AFM imaging technologies. Measuring the reflected waves from a sample determines impedance distribution, and therefore enables the observation of the uniformity of electrical characteristics.

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