

Discover Your Next Research Breakthrough in Advanced Materials

SOME BREAKTHROUGHS CANNOT WAIT. ACCELERATE YOUR PATH TO INNOVATION WITH CONFIDENCE.





Keysight Solutions for Academic Researchers

Your research is crucial for the discovery of new sciences, new solutions for real-world problems, and innovation that accelerates technological breakthroughs. As you perform iterative characterization, simulation, and measurement to confirm your hypotheses, confidence in every measurement is paramount.

Keysight Technologies advances research by professors around the globe through close university-industry collaboration and industry-leading hardware instrumentation **for highly accurate and reliable measurements.**

Researchers of radio frequency (RF) / microwave and high-speed digital circuit designs can also speed development and reduce costly prototyping errors through simulation with Keysight's leading electronic design automation (EDA) software.

No matter what breakthrough you are working on next, you can count on Keysight's wide range of robust test solutions and technical support expertise.

This brochure covers Keysight solutions for research in advanced materials science and engineering. Keysight also offers solutions for:

- RF, microwave, mmWave and Terahertz device characterization
- Key industry verticals such as 5G, biomedical sciences, energy, optical and photonics, and quantum engineering

For more information on how Keysight can help researchers go to:

www.keysight.com/find/education

Advanced Materials Science and Engineering

Scenario

Every material is unique in its electrical, optical, and mechanical properties. Materials include substrates in electronics; radar-absorbing materials (RAM) in aerospace and defense; and solar cells and batteries in automotive and energy. Other examples are liquid crystal displays and superconductors in industrial materials; food and other organic materials in food, agriculture, forestry, and mining; and bio-implants and human tissue in pharmaceuticals and healthcare.

Accurate characterization of material properties is crucial to providing researchers with valuable information that can help create next-generation technologies and products. Through advanced materials research, the discovery of materials like semiconductors, metals, polymers, ceramics, and compound semiconductors has accelerated innovation over the last century. Years of research conducted worldwide show how modifying these materials has led to the discovery of new and emerging materials with promising industrial benefits. Examples include carbon nanotubes, graphene, silicon carbide (SiC), and gallium nitride (GaN).

Keysight offers a broad range of solutions to meet the most demanding needs in advanced materials research. Our solutions include test methods and recommendations, instruments, fixtures, and software to help you efficiently and effectively characterize electrical and electromagnetic (EM) properties of your material under test.

Electromagnetic properties measurement solutions

Keysight offers a wide range of solutions to help you with highly accurate EM characterization of materials across a broad frequency range, from 20 Hz to the low terahertz.

Vector network analyzer (VNA)

Carry precision with you with
Keysight FieldFox handheld VNAs:

- wide range up to 50 GHz
- rugged build
- portable

Faculty spotlight

See how researchers ventured to the extreme polar regions to study sea ice — with Keysight FieldFox in tow.

Keysight Streamline Series USB VNAs provide a portable alternative to benchtop VNAs.

Reach for unrivaled excellence with
Keysight PNA VNAs:

- 900 Hz to 120 GHz
- PNA-L, PNA, PNA-X models
- extendable frequency up to 1.5 THz on PNA and PNA-X

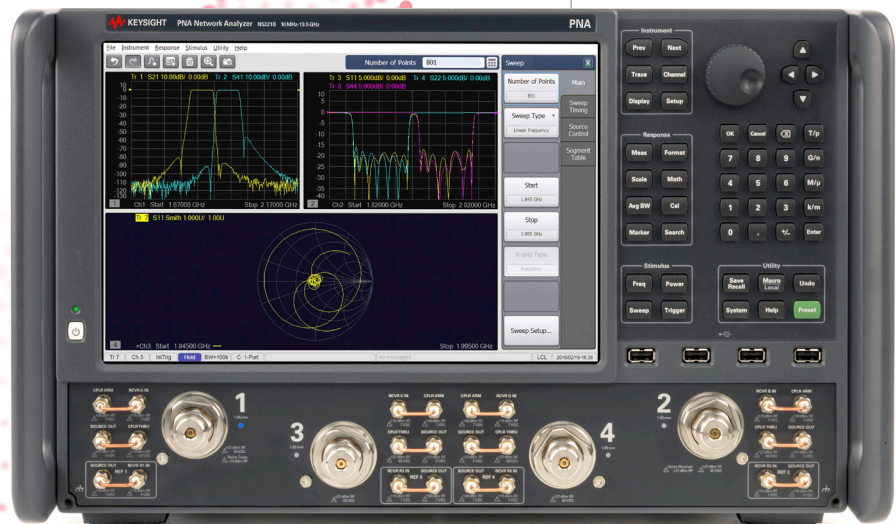
Faculty spotlight

Keysight VNA is key to artificial retina research — providing hope for the blind.

For lower frequencies, Keysight ENA VNAs are available for accurate, dependable measurements from 5 Hz to 53 GHz.



Find out more about
Keysight FieldFox



Find out more about Keysight network analyzers



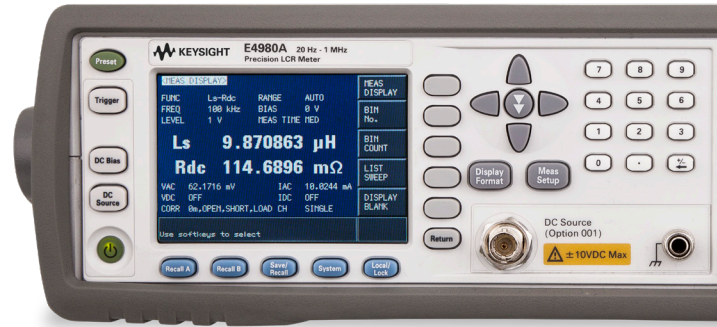
Further Reading: Basics of Measuring the Dielectric Properties of Materials

Precision LCR meter

- 20 Hz to 2 MHz
- 0.05% basic accuracy with superior measurement repeatability at low and high impedance



Find out more about Keysight's [E4980AL](#) and [E4980A](#) precision LCR meters



Impedance analyzer

- **E4990A:** 20 Hz to 120 MHz with industry-best 0.045% basic accuracy
- **E4991B:** 1 MHz to 3 GHz with 0.65% basic accuracy



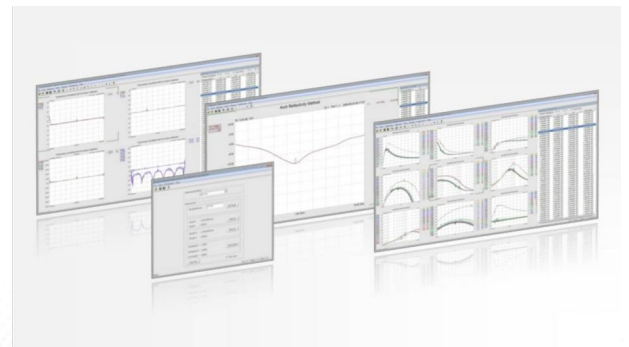
Further Reading: [Solutions for Measuring Permittivity and Permeability with LCR Meters and Impedance Analyzers](#)

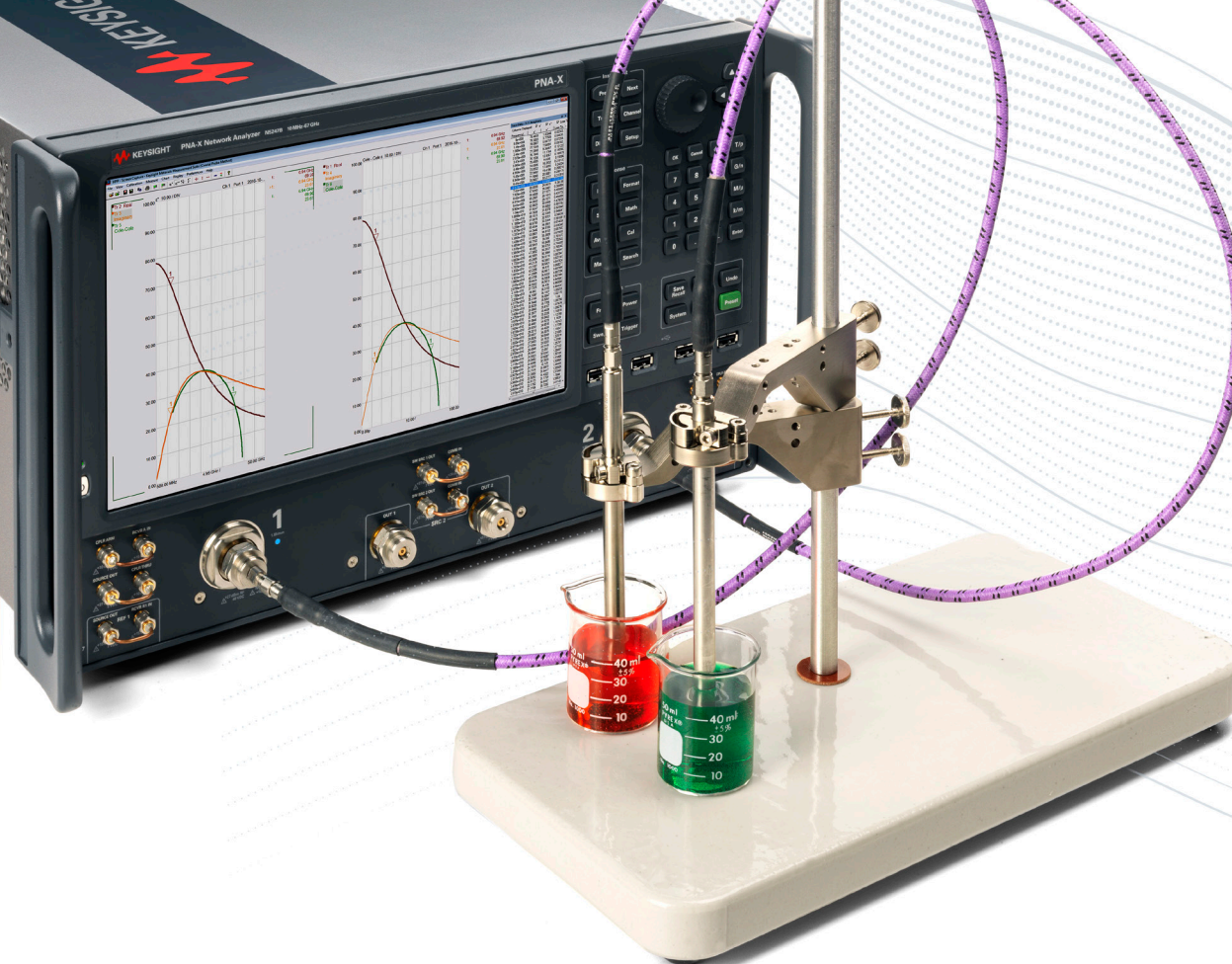
N1500 Materials Measurement Suite software

Keysight's N1500 Materials Measurements Suite software automates complex permittivity and permeability measurements. In one simple installation, the software is set for seven measurement methods: transmission line, free space, arch reflectivity, resonant cavity, coaxial probe, parallel plate, and inductance.



Further Reading: [N1500A Materials Measurement Suite](#)





Fixtures, probes, and resonators

The **N1501A dielectric probe kit** is suitable for permittivity measurement of “lossy” liquid, powder, and semi-solid materials with a Keysight VNA or impedance analyzer at frequencies of 10 MHz to 50 GHz. The kit equips researchers with a flexible choice of high-quality probes.

The **85072A 10 GHz split-cylinder resonator** can perform highly sensitive permittivity measurements at discrete frequencies with a Keysight VNA. The resonant cavity method is most suitable for low-loss materials. More resonator options are available from Keysight solution partners for measurements at microwave frequencies.

Various test fixtures are available for permittivity measurements of liquid or thin, flat sheets at lower frequencies: **16452A liquid material test fixture**, **16451B dielectric material test fixture**, and **16453A dielectric material test fixture**.

The **16454A magnetic material test fixture** works with a Keysight impedance analyzer to measure the permeability of toroidal core structures.



Further Reading: [LCR Meters, Impedance Analyzers, and Test Fixtures](#)

Electrical measurement solutions

Measurement accuracy at ultra-low signal levels is a primary requirement in the research and characterization of sensitive materials. High measurement resolution helps detect the slightest change in material behavior with respect to time, voltage, or temperature. Keysight offers a wide range of solutions to help with your advanced materials research. Our solutions fulfill most or all common test requirements, such as high accuracy, fast sampling speeds, and the capability to source both voltage and current over a broad range.



Source/measure units (SMU)

B2900A Series precision SMUs with EasyEXPERT group+ are entry-level analyzers that feature current resolution down to 10 fA, wide voltage / current ranges up to 210 V, and 3 A DC / 10.5 A pulse. You can combine multiple SMUs, up to eight channels. EasyEXPERT group+ software on PC simplifies measurement and analysis.



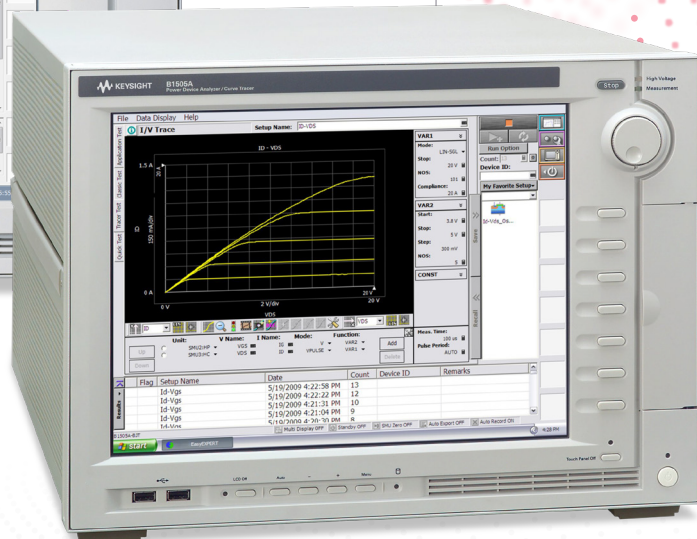
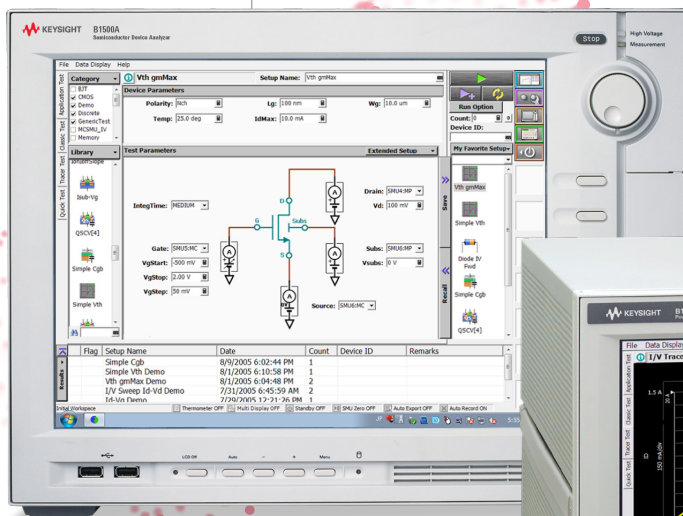
E5270B and E5260/62/63A precision IV analyzers with EasyEXPERT group+ are high-performance analyzers that feature a current measurement capability as low as 0.1 fA and voltage as low as 0.5 μ V. SMU scalability is available for advanced IV characterization. **EasyEXPERT group+** software on PC simplifies measurement and analysis.

Advanced device analyzers

Keysight's **B1500A** and **B1505A** are flexible, all-in-one advanced device analyzers with 15-inch touch screens. With configurable modules of up to 10 slots, the analyzers are easily scalable to your needs. The built-in **Keysight EasyEXPERT group+** graphical user interface (GUI)-based software simplifies complex device characterization instantly with hundreds of built-in, ready-to-use application tests. With the analyzers' built-in storage, you can efficiently carry out repeated device characterization and export measurement data for reporting and further analysis.

The **B1500A semiconductor device parameter analyzer** is your complete semiconductor device characterization system. It supports IV, CV, QS-CV, pulse / dynamic IV, and all-around characterization from basic to cutting-edge applications.

The **B1505A power device analyzer / curve tracer** is your one-box solution for power device evaluation with broad measurement ranges from sub-pA to 10 kV/1500 A. Its capabilities allow the evaluation of novel devices such as insulated-gate bipolar transistor and wide-bandgap materials like GaN and SiC.



Faculty spotlight

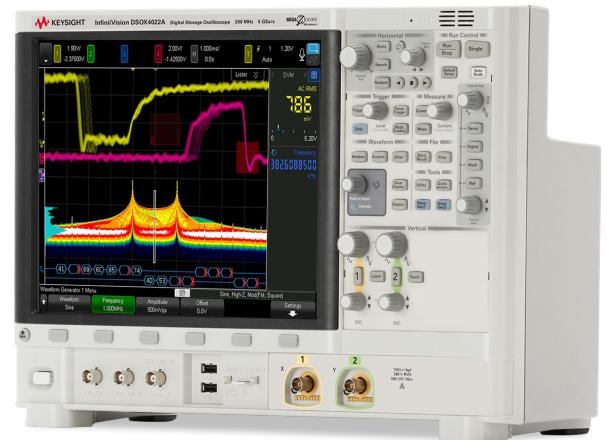
See how **Keysight's** high-precision B1500A and B1505A were key to helping researchers develop an accurate SPICE model for GaN devices.



View a [quick comparison between B1500A and B1505A](#)

Oscilloscopes / analyzers / meters

We built **Keysight InfiniiVision** oscilloscopes around our patented technology to give you the fastest waveform update rates — an important specification to help you capture infrequent glitches in your design. When used with the N2820A high-sensitivity current probe, it lets you capture current as low as 50 μA . This capability makes the oscilloscope ideal for sensitive low-current applications such as time of flight and pulsed IV measurements.



B2985A / B2987A electrometers can measure resistances up to 10 P Ω , making them great for volume or surface resistivity of insulation materials. For AC line noise elimination and higher measurement accuracy, you can select battery-operated versions of the electrometer.

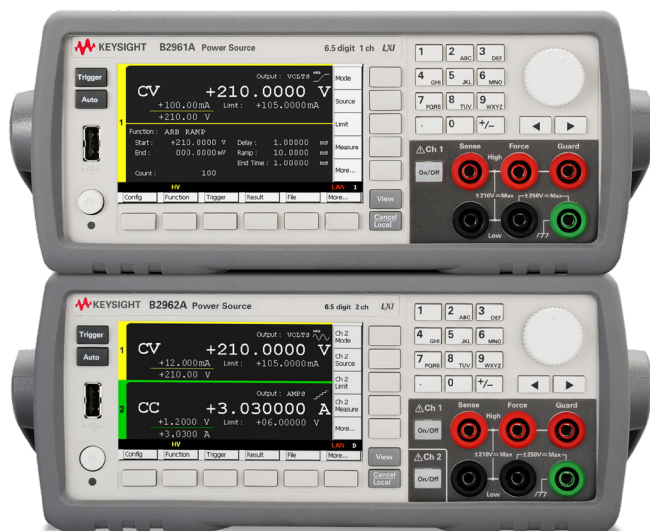
The **34420A micro-ohmmeter** can measure resistances down to 100 n Ω . That capability makes it ideal for four-point probe measurements of materials such as metal or highly doped semiconductors.



Keysight precision LCR meters and impedance analyzers provide measurements for material characterization up to 0.045% basic accuracy. They are suitable for CV and AC impedance spectroscopy measurements.

Generators / power supplies

Keysight offers a broad range of power supplies, waveform generators, and pulse generators. The Keysight low-noise power source is especially suitable for advanced materials research because of its extremely low noise floor of 10 μVrms and 1 $\text{nVrms}/\sqrt{\text{Hz}}$ (at 10 kHz).



The **B2961A / B2962A low-noise power source** provides wide bipolar output ranges of 100 nV to 210 V / 10 fA to 10.5 A — and a flexible arbitrary waveform-generation capability. These capabilities make it a suitable voltage or current source for a wide range of material electrical characterization methods, including four-point probe, time of flight, IV, Van der Pauw, and Hall effect measurements.



Find out more about other **Keysight generators, sources, and power products**

Switch matrix

The B2200A / B2201A / E5250A low-leakage switch matrix line expands the measurement capability of instruments like the B1500A semiconductor device analyzer to create an automated measurement solution with flexible input / output configurations. The large number of channels and low-cost stress sources allow efficient reliability testing of hundreds of devices in parallel, saving cost and time and achieving accurate, consistent results. The B2200A / B2201A provides a distinctive compensation feature that ensures high accuracy of capacitance measurements.



Further reading: **Challenges and Solutions for Material Science/Engineering Testing Applications**





BRINGING YOUR IDEAS TO LIFE WITH INTEGRATED DESIGN AND TEST

PathWave Product Development Software

Engineering leaders know that every step in the path to new electronic product development is crucial — from design and simulation to verification and manufacturing. Unfortunately, measurement results from one step do not seamlessly transition to the next. Test engineers spend hours correlating measurements from their design teams. Software engineers write workarounds because their hardware and software do not natively talk to each other. Most organizations use standalone products for design, test, measurement, and monitoring. This siloed structure creates disconnected and inefficient workflows and is a major cause of frustration.

Connected, agile design and test is a groundbreaking way to approach the development of electronic systems. It combines new software, new workflows, and powerful automation tools in a way that transforms legacy processes and yields substantial productivity and equipment utilization improvements. Integrating design and automation software throughout a product development workflow increases efficiency by accelerating routine tasks. Keysight PathWave software is a systems engineering platform that connects design and test, providing common data models and open standards to accelerate product development life cycles.

PATHWAVE

To learn more, go to:

www.keysight.com/find/pathwave



Bring your design ideas to life

PathWave Design is a collection of electronic design automation software tools that connect circuit design, EM analysis, and system simulation. PathWave Design accelerates product development by reducing the time engineers spend in the design and simulation phase.



Automate, accelerate, and scale your tests

PathWave Test is a collection of test software that connects teams and test stations. Scalable from a single user to a global enterprise, PathWave Test accelerates your test workflow. It gives you the power to collaborate and manage test projects from your web browser.



Perform analytics for improved decision-making

PathWave offers powerful analytics to help you find, visualize, and understand big data to improve business knowledge. It includes visualization tools, real-time asset monitoring, and advanced algorithms that anticipate anomalies to drive process improvements and increase productivity.



YOUR PARTNER IN EDUCATION SOLUTIONS

Keysight Services

Calibration and repair services

Having the right measurement solution is only the beginning. Design engineers count on repeatable results across work groups to avoid discrepancies that can impact development cycle time, time to market, and budgets.

Manufacturing strives to meet production goals, but inaccurate measurements can affect yield and product quality. Keysight calibration and repair services keep instruments operating to warranted specifications over their lifetime, ensuring accurate, repeatable measurements across R&D and manufacturing.

Our partnership with you

Keysight offers a broad portfolio of services and support to address all your test equipment needs:

- Startup assistance and training help you quickly and effectively use your new equipment.
- Calibration and warranty assurance plans provide coverage for 5, 7, or 10 years.
- Flexible service delivery includes on-site mobile labs that reduce your calibration turnaround time from days to hours.
- Premium used equipment includes the same high performance and three-year standard warranty as new units.
- Trade-in programs (available on both Keysight and non-Keysight models) offer you significant credits to upgrade to the latest Keysight technology.

To learn more, go to:

www.keysight.com/find/services

