AEROLASER



LIFE TIME SPEC

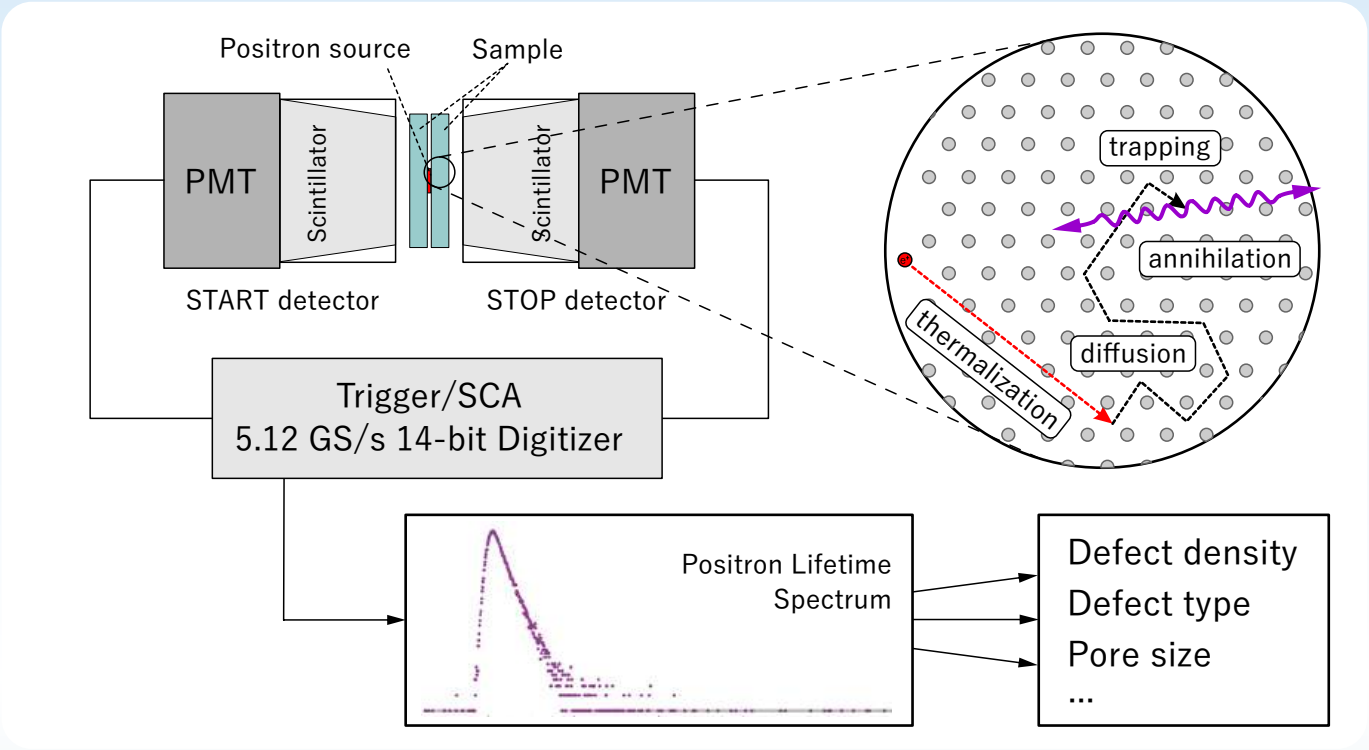
TABLETOP POSITRON LIFETIME SPECTROMETER
FOR NON-DESTRUCTIVE MATERIAL ANALYSIS

LIFE TIME SPEC

DETECTING OPEN VOLUME ON THE ATOMIC SCALE

Positron Annihilation Spectroscopy - The Search for Defects in Matter

Today, materials researchers and engineers increasingly aim to optimize materials at the nanometer scale. Positrons – the antiparticles of electrons – provide unique insights into the microstructure of materials. When injected into a material, they become trapped in tiny open-volume defects such as vacancies or nanovoids. By measuring the positron lifetime before annihilation with an electron, **Positron Annihilation Lifetime Spectroscopy (PALS)** allows these nanoscale defects to be detected and characterized. The technique is non-destructive and can be applied to a wide range of materials without complex or time-consuming sample preparation.



Life Time Spec - The first tabletop PALS spectrometer

Up to now, PALS was mainly limited to physics institutes and large research facilities due to the complexity of the instrumentation. With the **Life Time Spec**, PALS becomes accessible as a **compact tabletop system** suitable for everyday laboratory use. The instrument operates with low-activity **^{22}Na positron sources well below regulatory exemption limits**, allowing measurements in standard laboratory environments without the need for dedicated radiation monitoring or controlled areas.

All required electronics are fully integrated into the instrument, including the high-voltage supply for the photomultiplier tubes (PMTs), trigger logic, single-channel analyzers (SCAs), and constant fraction discriminators (CFDs). No external nuclear electronics are required, which significantly simplifies setup and operation. The system is set up by the powerful MaDa+ software, which also displays all relevant parameters and the PALS spectrum.

The detector signals are digitized using a **DRS4-based waveform digitizer operating with 14 bit resolution at 5.12 GSamples/s**, enabling precise timing measurements and detailed pulse analysis. Filtering and binning are not fixed during acquisition and can be optimized afterwards during data evaluation.

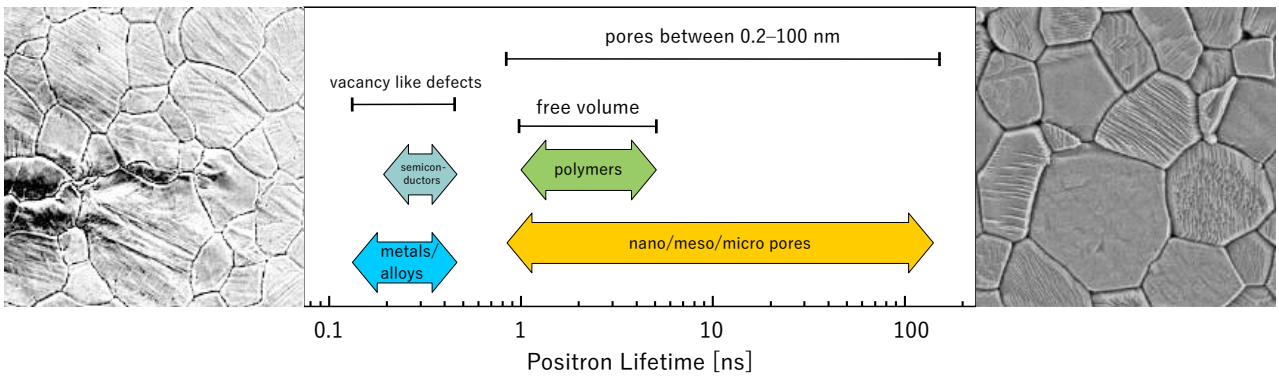
Applications

PALS can detect open volumes in solid-state matter over several orders of magnitude from atomic defects (< 0.3 nm) up to mesopores (100 nm). As a result, PALS enables a comprehensive micro-structural assessment, providing information on:

- defect density
- defect type
- free volume in polymers
- pore size and distribution
- impurities
- fatigue and aging

These parameters provide a direct link between microstructure and material performance. This combination of sensitivity and quantitative output makes PALS highly valuable for both R&D and production environments. Key applications include:

- Early-stage fatigue detection in metallic alloys enabeling fatigue lifetime prediction
- Sensitive detection of plastic deformation, even at very low strain levels
- In-situ monitoring of deformation and fatigue under mechanical load
- Quantification of free volume and glass transition behavior in polymers
- Analysis of vacancies and impurities in semiconductors
- Characterization of porous systems (open and closed porosity)
- Sintering process optimization



Driving Innovation in Materials Research and Development

PALS provides actionable microstructural information that supports both materials innovation and robust manufacturing. Typical fields of application include:

- **Alloy development** Accelerates the optimization of alloy concepts - supporting improved strength, ductility, and fatigue performance.
- **Development of advanced functional materials** Enables targeted tuning of microstructure by assessing nanoscale free volume and porosity.
- **Semiconductor R&D** High sensitivity to vacancy-related defects, allowing process and material changes to be evaluated at an early stage.
- **Process control and optimization in sintering** Monitoring densification and nano-porosity, enabling improved parameter selection, higher yield, and consistent part quality.

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Precision is our Mission

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Life Time Spec - a powerful tool for material developers and scientists

PALS is a powerful and non-destructive tool for advanced materials characterization. The method is highly sensitive to atomic lattice defects and open-volume structures on the nanometer scale, providing unique insight into the microstructure of solids. Across a wide range of application fields, PALS helps researchers and engineers reveal microstructural features that are difficult or impossible to access with conventional methods - supporting materials development, process optimization, and reliability assessment.

Specifications

Detection technique:	Positron Annihilation Lifetime Spectroscopy (PALS)
Geometry:	2-detector setup, 180°, 90°, 120°. Extension up to 4 detectors possible
Scintillator material:	PMMA, BC422Q0.5
PALS data acquisition:	Digital (DRS4/FPGA) at 5.12 GS/s, 14-bit resolution, 2-4 channels parallel
Time resolution:	<150 ps
Trigger/SCA/CFD:	Integrated, digitally controlled by software MaDa+ on external PC
HV supply for PMTs:	Integrated, digitally controlled
Data filtering/ background reduction:	Digital physical filters
Data format:	Parameterized pulses. Filtering and binning possible after measurement
Interface:	Server/Client based, TCP/IP - ProtoBuf
API:	C/C++, Python, Java via ProtoBuf
Weight and dimensions:	5kg, portable (wdh: 37 cm × 27 cm × 18cm)
Power requirements:	110VAC/230VAC, <20W

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