Atomic Oxygen Simulation System
AO-SimTek 2019™

SimulTek Research

At SimulTek Research we offer a complementary range of instruments for reliable, accelerated multi-environmental laboratory testing of spacecraft materials, systems and components in simulated LEO/GEO/HEO space environments.

The atomic oxygen and UV radiation are a harsh damaging factor in LEO Environment for all exposed surfaces. The atomic oxygen simulation is a fundamental activity since it can reveal the efficiency of materials and coatings for space application.

The basic AO-SimTek 2019™ space simulator system could be used in many different applications, including ground-based accelerated testing. The general design of 5 eV SimTek™ atomic oxygen systems includes the following four major modules: a stainless steel vacuum/test chamber, a pulsed valve assembly, a pulsed CO_2 laser, a laser beam focusing system, and control electronics.

Applications

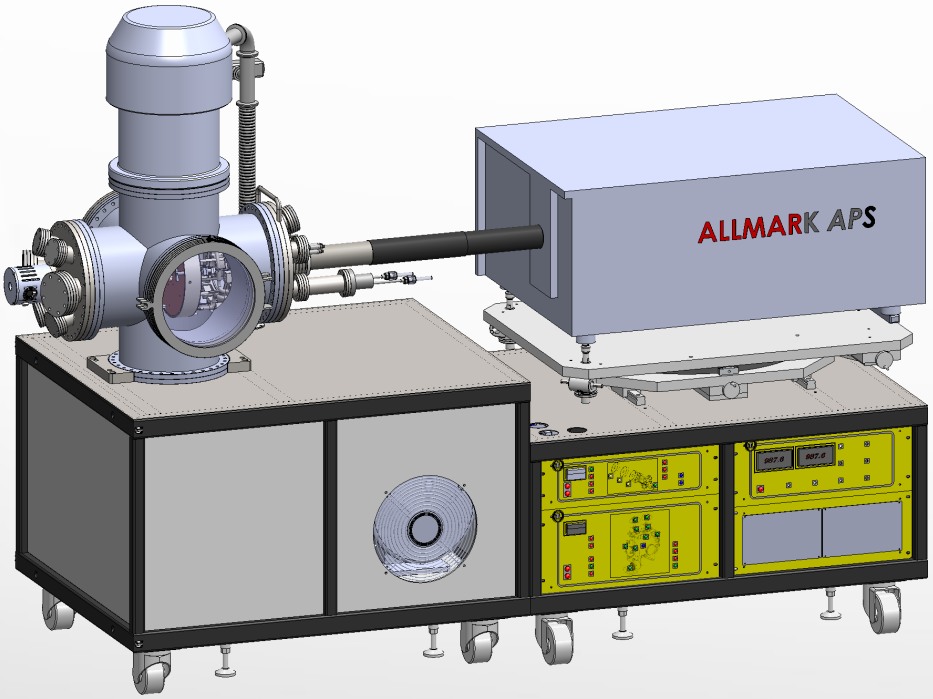
- Bombardment of surfaces with O-atom beams
- Study of the interaction of high velocity atomic oxygen atoms with materials
- Study of the degradation of spacecraft external surfaces in space conditions (Low Earth Orbits)

Main Features

Beam velocity	8 km/s (5 eV)
Beam flux	$(3\text{-}4)\times10^{15}$ atom/cm^2 @ 40 cm
Beam area	~380 cm^2 @ 40 cm
Beam flux	$(5\text{-}8)\times10^{15}$ atom/cm^2 @ 25 cm
Beam area	~110 cm^2 @ 25 cm
Base pressure	< 1.0×10^{-7} Torr
Max pulse rate	1-6 Hz*
Temperatures	-160 to +250°C

* The maximum pulse rate is limited by laser and pumping speed of vacuum system

- Optional: Simultaneous AO exposure with VUV/ NUV radiation
- Optional: Variable-energy electron and proton radiation sources
- Optional: *In-situ* AO flux measurement sensor (QCM or Time-of-Flight technique)
- Optional: *In-situ* analytical equipment for characterization of degradations occurred
- Optional: RGA mass spectrometer
- Optional: Load-dock chamber with sample manipulator / transfer



AO-SimTek 2019™ *(Basic)*

Vacuum/Test Chamber
Vacuum System
CO_2 Laser
Laser Optical System
Hyperthermal AO Source
Sample Holder with T-cycling
Support Electronics
Data Acquisition System
Control Software

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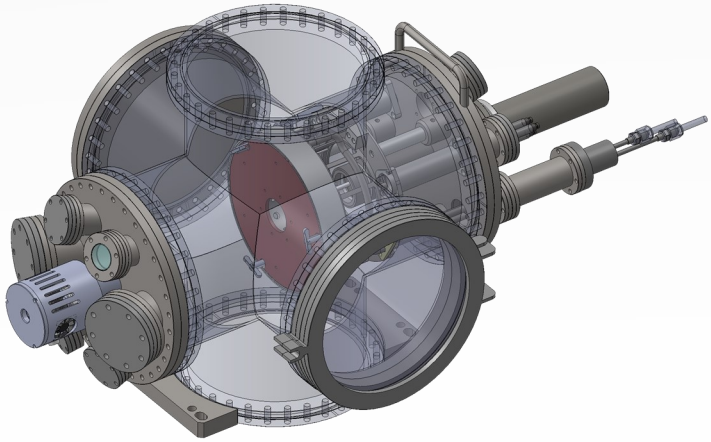
Vacuum/Test Chamber

A 6-way cross with all ports axes passing through the center point is recommended as the vacuum chamber for materials testing. The vacuum/test chamber is manufactured from Stainless Steel 304 with vacuum flanges providing for high-vacuum conditions. The chamber has internal welds and is polished to minimise outgassing.

All flanges are of ConFlat (CF) type with copper gaskets sealing. Numerous ports are provided for

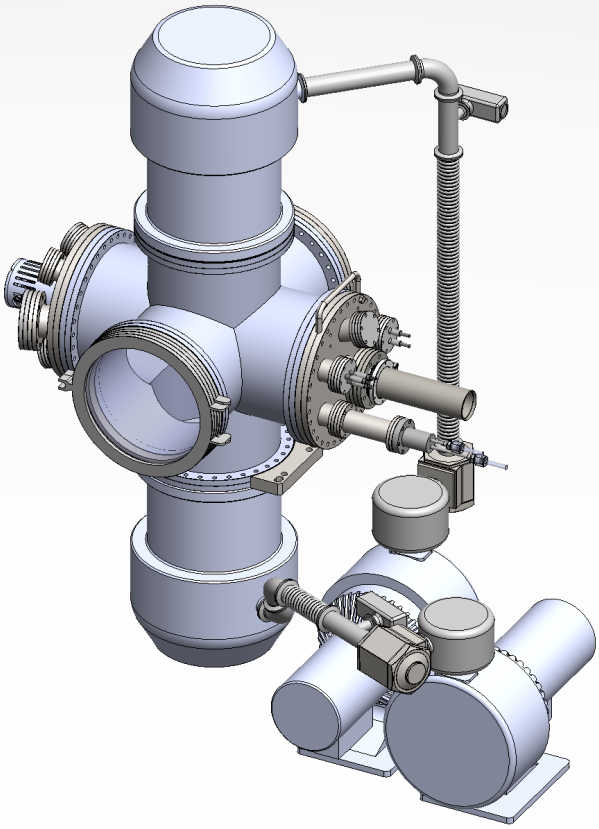


gauges and analysis tools.

The vacuum system allows to maintain the required pressure during AO test exposure, as well as to carry out quick pumpdown procedure. The vacuum chamber is pumped with an oil-free

pumping system including two mechanical scroll pumps and two turbo pumps. A number of different valves, pressure gauges and controllers is incorporated into the vacuum system as required.

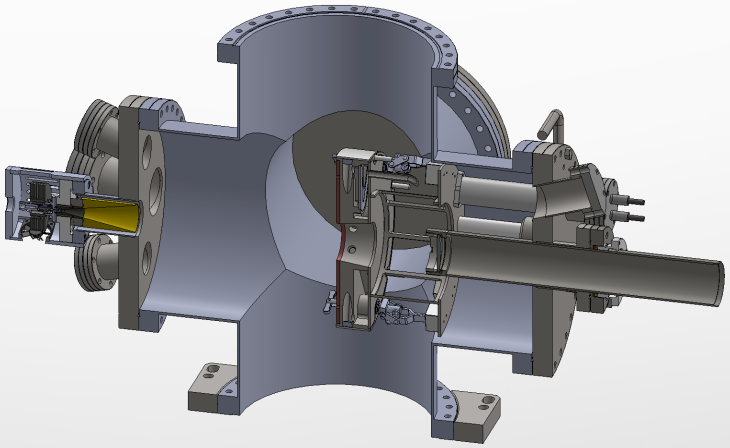
The chamber is extendable, i.e. it would permit installation of additional irradiation sources,



measurement and control instrumentation for *in-situ* monitoring of various properties and parameters of materials during exposure.

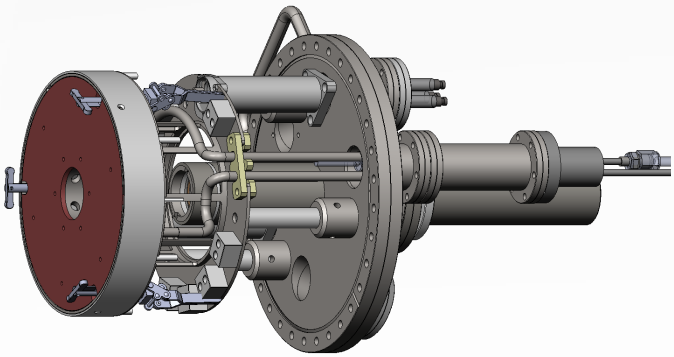
Sample Holder

The standard sample manipulator handles a sample holder plate of ∅200 mm. Options such as sample holder heating and cooling can be added for enhanced performance.



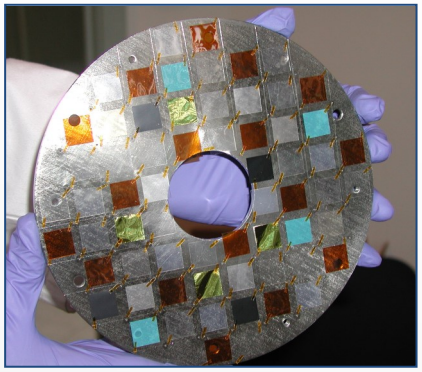
It is used for heating, cooling, constant temperature maintenance, thermal cycling, and thermal shock testing of the samples. The effective temperature range that can be achieved using this system is from, at least, -160ºC to +250ºC. Temperature can be measured and sustained with 1º accuracy.

In the cooling mode, cooling is provided by liquid



nitrogen supply into the system. Inside the sample holder/thermal control platform, there is a hermetically sealed volume of ~1 liter, which is connected to the liquid nitrogen system via an automated cryo valve. This allows temperature to be sustained with an accuracy of 3º.

The sample manipulator is firmly installed at 25 cm from the AO Source. The sample manipulator is mounted on the 12” back flange of the main 6-way cross and is equipped with all necessary electrical, thermocouple, liquid nitrogen (LN_2), and motion feedthroughs.



Sample loading

In the basic AO -SimTek 2019™ system, sample entry can be made through a 12” hinged flange (o-ring sealed).

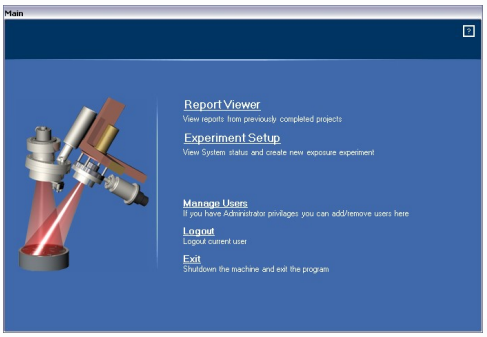
Customized testing rigs and sample holder set-ups for planetary samples and larger samples are available on request.

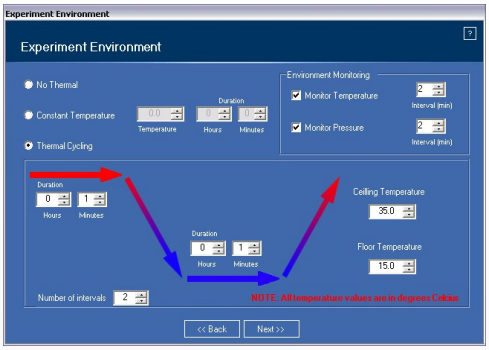
Automation

All of the components of the AO-SimTek 2019™ system are controlled by developed support electronics and control blocks. The PLC module performs the operation and control of every electrical socket to ensure the proper operation of connected devices.

A comprehensive automation software package is available for the AO-SimTek 2019™. The simulator facility is fully computer-controlled and operated by the original Atomix™ software developed and offered by SimulTek Research. The software package enables automated control over almost all functions of the system to enable recipe driven processes (automatic pump down, sample change, service mode, venting, etc.).

The Atomix™ software consists of a number of control windows for experiment creation and running in manual and/or automatic operation mode.





Alternatively, the system could be operated manually with power supplies and controllers installed in electronics rack.

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Hyperthermal AO Source

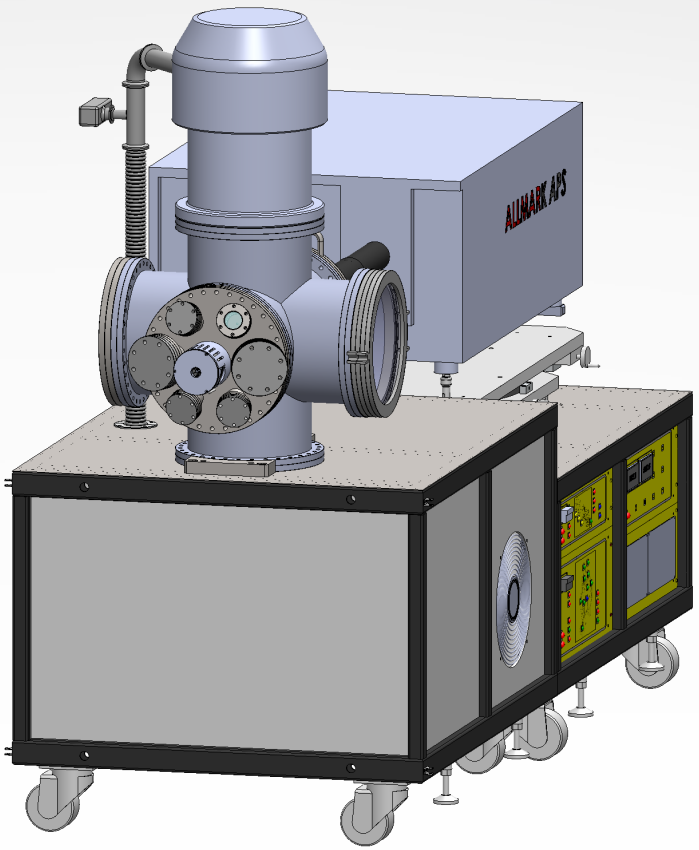
The laser detonation source offers one of the most effective methods for simulation of atomic oxygen erosion in the LEO space orbits by providing high fluxes of oxygen atoms in the energy range of ~5 eV.

The AO source system, which bolts directly to the main vacuum chamber, consists of:

- a pulsed AO beam source valve/nozzle subsystem that is mounted on the side of the vacuum/test chamber;
- a CO_2 IR laser producing electromagnetic pulse at a wavelength of 10.6 μm with a maximum pulse energy of ~6 J at 1-6 Hz repetition frequency;
- a laser beam delivery and focusing subsystem that is mounted from the opposite side of the vacuum chamber.

The AO source operates without the optical system and IR mirrors and the ZnSe focusing lens is used as a port view at the same time. In the coaxial mode the laser beam energy loss could be minimized to ~2-3%.

The high performance of the developed AO beam source is confirmed by a 10-50 accelerating factor in simulating the erosion effects of various surfaces in LEO.



Technical specifications of the basic AO-SimTek 2019™ system

	Parameter	Specification
Vacuum System	AO chamber volume, m^3	~(0.3-0.7)
	Pumping speed (N_2), L/s	1,000-4,100
	Basic vacuum, Torr	< 10^{-7}
	Distance from nozzle to samples, cm	25-45
IR Laser	Laser energy, Joule	5.5-6.0
	Laser wavelength, mm	10.6
	Laser repetition frequency, Hz	1-8
Atomic Beam	Energy, eV	~5
	Beam flux, atom/cm^2/s	(3-5)×10^{15}
	Accelerating factor	10-50
	AO beam diameter/ sample size	200-225 cm^2
Thermal Cycling	Temperature range, °C	-160/+250
	Temperature control accuracy, °C	±1

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