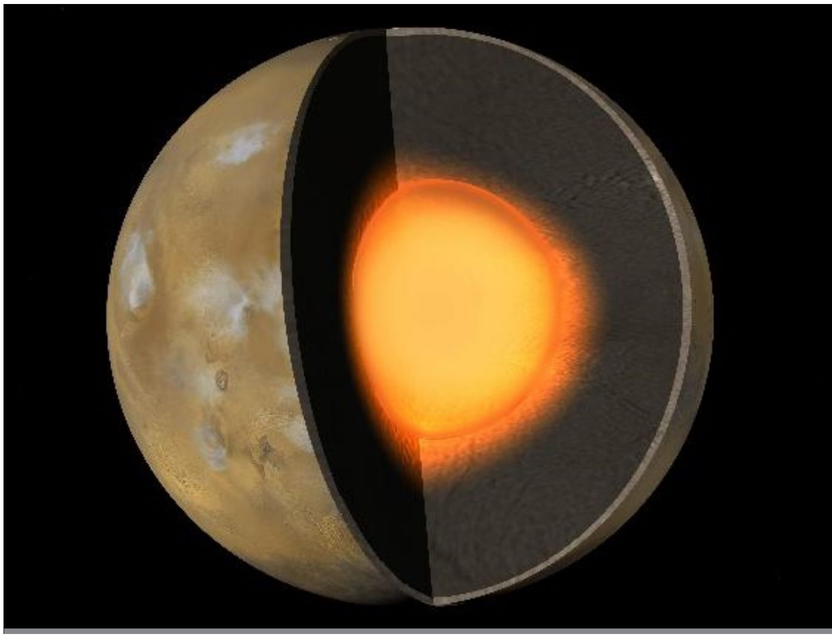


National Aeronautics and Space Administration

TECHNOLOGY SOLUTION

Materials and Coatings

'Diamond Maker' Technology Simulates Subsurface Geology in Laboratories

Allows researchers ability to speciate natural elements while investigating geologic processes

Innovators at NASA Johnson Space Center have developed a novel, double capsule control system that allows for high temperature and high-pressure geologic research to be performed in a contained environment relevant to a broad array of materials. It can also yield the speciation of redox-sensitive elements and is even capable of creating geologic conditions necessary to birth diamonds when used in conjunction with a multi-anvil press.

Users of this technology can specify a wide range of oxygen fugacity (fO2) values during experiments. fO2 is a measure of rock oxidation that influences planetary structure and evolution and contributes directly to the study of our galactic origins. It commands some of the fundamental chemical and physical properties in planetary materials, including electrical conductivity, grain-growth kinetics, and phase stability.

This technology was previously used to replicate fO2 environments relevant to core samples from the Moon and those obtained from the Earth's deep crust. It may be further extended to higher pressure and higher temperature studies where greater control of a specific experimental sample environment might allow unique chemical bonding and reactivity that would not be possible in systems that utilize the standard approaches.

BENEFITS

- Improves simulation of more extreme planetary interiors by yielding higher temperature (1600+C) and pressure values (20+GPa).
- Allows fO2 to be specified across wider ranges of values relevant to experimental samples.
- Promotes unique chemical bonding and reactivity that may not be possible in other systems.
- Yields speciation of redox-sensitive elements.
- System has been trained on core samples from the Moon and the Earth's deep crust.
- Accelerates research into stellar neighborhood and galactic origins.

APPLICATIONS

The technology has several potential applications:

- High pressure, high temperature geological studies
- Materials science and engineering
- Melt synthesis
- Metal-silicate or mineral-melt partitioning
- Phase equilibria studies
- Pharmaceutical research
- Synthesis of new mineral and chemical compounds

THE TECHNOLOGY

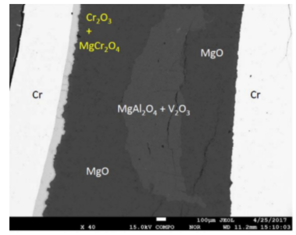
Given the significant impact of fO2 on material properties, it is important to perform studies at fO2 values relevant to the sample of interest. However, current systems used to control fO2 in solid media assemblies (e.g., sliding sensors, graphite capsule buffering) have limited ability to produce the wide fO2 ranges necessary to simulate more extreme planetary interiors.

NASA's fO2 control system implements a modified double capsule design that utilizes a wide range of solid metal-oxide buffers to control fO2 across a wide range of conditions. The approach is a modification of the previous double capsule design wherein the outer capsule itself acts as the metal component of the buffer assemblage, and the inner capsule – to which the astromaterial sample of interest is placed – resides within the outer capsule.

To achieve higher experimental temperatures above the melting point of more traditional noble metal capsule materials, outer capsules of the control assembly are comprised of refractory (high melting point) metals such as Ni, Co, W, Fe, Mo, V, Cr, Nb and Ta. Resultant experiments have reliably achieved temperatures exceeding 1600 degrees C, and when used in conjunction with a multi-anvil press, system pressures of over 20 GPa can be obtained – lending researchers the ability to simulate on or off-world geologic conditions previously difficult to obtain in a laboratory.

NASA's fO2 control system was developed to enable high pressure, high temperature experimental studies of astromaterials at fO2 values relevant to the sample of interest. However, it may also be useful for the synthesis of materials where fO2 control is required (e.g., synthesis of crystal structures that might be stable under higher oxygen pressure). Further use cases may include mineral or melt syntheses, metal-silicate or mineral-melt element partitioning, phase equilibria studies, and the possible development of new chemical and mineral compounds that could not be manufactured in laboratories before.

This fO2 control system technology is at a technology readiness level (TRL) 6 (system/subsystem prototype demonstration in a relevant environment). The innovation is now available for your company to license. Please note that NASA does not manufacture products itself for commercial sale.



Shown: back-scatter detector image of a double capsule experiment with a Cr outer capsule (white), C2O3 layer at left inside edge of Cr capsule (light gray), and MgO inner capsule containing MgAl2O4+V2O3.

PUBLICATIONS

Patent No: 11,506,620

More Information

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