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Status of Developments - Toward Long-Lived Venus Landers

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Abstract

Missions to the surface of Venus have had limited life due to the extreme environmental conditions. The short life has limited the science that is achievable, and there are gaps in some science, such as seismology, which is enabled by long life. This work summarizes technical advances that are preparing us for long-duration (weeks to months) Venus surface missions.

1. Introduction

Exploration of the surface and interior of Venus possess unique challenges to scientists and spacecraft designers. The cloud layers and dense atmosphere make standard remote sensing practices challenging or impossible. Surface conditions are extremely challenging for landers, none of which have survived for more than ~2 hours. NASA has begun tackling these challenges by using a new approach that leverages decades on investment in high temperature sensors, electronics and systems. This briefing will discuss progress on the development of components, subsystems and systems that target extended (weeks to months) operations on the Venus surface.

2. Technology Developments

Recent developments by NASA, and others, are making progress toward overcoming the noted challenges. For example, high temperature sensors with heritage back to aeronautics applications have been modified and demonstrated to function in Venus conditions. Wide band gap, SiC based electronics have been demonstrated to function successfully for extended periods of time at over 500C and in the reactive chemistry of the near-surface Venus atmosphere. In addition to electronics a number of other subsystems are in development [1], [2], including power in the form of high temperature batteries and power management devices, communications including antennas, transmitters and other components, materials [3], and structures and mechanisms.

Some examples and recent progress: the world's first demonstration of stable electrical operation of semiconductor integrated circuits (ICs) for over one year at 500 °C in air atmosphere was achieved, including operation of a packaged SiC clock circuit central to LLISSE operation. This level of complexity is more than a factor of 7 beyond what was previously shown. This circuit has also shown 60 days of full operations in simulated Venus surface conditions unshielded and open to the environment.

Electronic circuits with the capability to provide basic functionality for LLISSE have been designed, fabricated and tested. This includes transistors associated with lower frequency communications. LLISSE sensor development has been on-going as well with several of the LLISSE sensors reaching a higher level of maturity. For example, 4 chemical species sensors have shown operation for 60 days in Venus simulated conditions with stable response and limited change in calibration over the test period.

These are examples of activities under NASA's Long Lived Insitu Solar System Exploration (LLISSE) project, HOTTech, and other NASA funded efforts.

3. Future Applications

If the ongoing developments continue on the trend they have been to date, one can envision near term (<10 year) applications that will acceleration and expand our paradigm about Venus surface exploration. The capabilities under development will usher in the ability to make temporal measurements to help us understand the mysteries about the complex Venus atmosphere and climate. They will enable, for the first time ever, the capture of data that will reveal the seismicity of Venus and allow for our first glimpses into the interior structure.

4. Summary and Conclusions

Progress continues to be made toward a complete lander system that can operate in the harsh Venus surface conditions. Such progress will enable surface missions that last months to be available in the near term

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References

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