LOW INTENSITY HIGH TEMPERATURE (LIHT) SOLAR CELLS FOR VENUS EXPLORATION.

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Current solar cells do not function effectively in Venus aerial and surface environments, and are not suitable for long-duration Venus aerial missions. In anticipation of objectives in the next decadal survey, the Venus Exploration Analysis Group (VEXAG) has recommended to NASA to develop the required critical spacecraft systems, subsystems and payload instruments that can survive and operate in Venus harsh aerial and surface environments for long duration. Therefore, we have proposed to develop Low Intensity High Temperature (LIHT) solar cells that can function and operate effectively in Venus atmospheric conditions at various altitudes, and survive on the surface of Venus, where the temperature reaches 450-500°C. [1] The projected performance advantages of the proposed LIHT solar cells are that they: a) operate efficiently (> 16%) at high temperatures (i.e., 300°C), b) operate effectively at the low solar intensities characteristic of Venus environments, c) survive and operate in Venus corrosive environments, d) provide long operational capability (> six months) at 25km Venus altitude where temperature is 300°C, and e) survive at Venus surface temperature for more than a month.

The goal is to develop and mature LIHT photovoltaic (PV) technology that will enable and significantly enhance performance, and reduce technical risk, for in situ mission concepts that would explore high-temperature environments with temperatures approaching 500°C or higher. This technology development would expand the range of science that can be achieved at Venus. The high-temperature solar cells developed here would also benefit solar concentrator photovoltaic power systems in terrestrial applications.

We are developing a dual-junction high-temperature GaAs/GaInP solar cell. A detailed schematic of the two-junction solar cell structure is shown in Fig. 1. The novel features of the proposed cell include: a) high bandgap semiconductor materials (GaAs/GaInP), that are optimized to capture solar irradiance efficiently at Venus, b) high-temperature tunnel junctions, c) high-temperature solar cell contacts, d) anti-reflection coatings, and e) Al_2O_3 corrosion protection coatings. This advanced LIHT cell would capture the red-shifted peak of the Venus spectrum in the GaInP layer and the remaining longer wavelengths in the GaAs layer. Layers will be current matched by simple layer thickness modifications to optimally capture the full Venus solar spectrum. This cell will also demonstrate more robust, high temperature electrical contacts that have eluded previous designs. [2] This type of solar cell employs the high-band-gap semiconductor materials similar to state-of-the-art triple junction solar cells. However, this cell does not contain the Ge bottom sub-junction of the current state-of-the-art triple junction solar cells. This modification improves high-temperature performance of the cells.

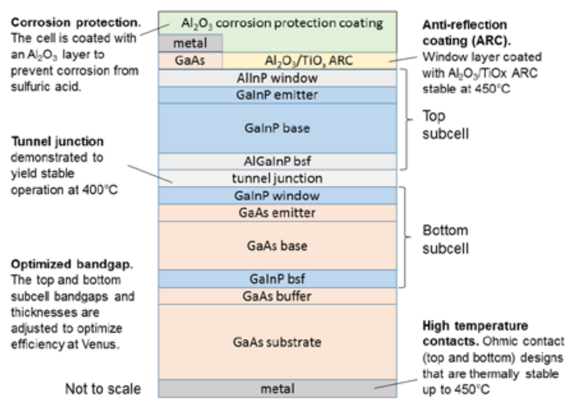

Figure 1: Low Intensity High Temperature (LIHT) Solar Cell designed to survive and provide optimal power in a Venus environment

References:

[1] Geoffrey, A.L. and H. Emily, (2013) *Analysis of Solar Cell Efficiency for Venus Atmosphere and Surface Missions*, in 11th International Energy Conversion Engineering Conference. American Institute of Aeronautics and Astronautics.

[2] Sun, Y., et al. (2016) *Thermal stability of GaAs solar cells for high temperature applications*. in 2016 IEEE 43rd Photovoltaic Specialists Conference (PVSC).