A SURVEY OF THE RAPIDLY EMERGING FIELD OF NANOTECHNOLOGY: POTENTIAL APPLICATIONS FOR SCIENTIFIC INSTRUMENTS AND TECHNOLOGIES FOR ATMOSPHERIC ENTRY PROBES

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ABSTRACT

The field of Nanotechnology is well funded worldwide and innovations applicable to Solar System Exploration are emerging much more rapidly than thought possible just a few years ago. This presentation will survey recent innovations from nanotechnololgy with a focus on novel applications to atmospheric entry science and probe technology, in a fashion similar to that presented by Arnold and Venkatapathy [1] at the previous workshop forum at Lisbon Portugal, October 6-9, 2003.

Nanotechnology is a rapidly emerging field that builds systems, devices and materials from the bottom up – atom by atom – and in so doing provides them with novel and remarkable macro-scale performance. This technology has the potential to revolutionize space exploration by reducing mass and simultaneously increasing capability.

Thermal, Radiation, Impact Protective Shields: Atmospheric probes and humans on long duration deep space missions involved in Solar System Exploration must safely endure 3 significant hazards: (i) atmospheric entry; (ii) radiation; and (iii) micrometeorite or debris impact. Nanostructured materials could be developed to address all three hazards with a **single** protective shield, which would involve much less mass than a traditional approach. The concept can be ready in time for incorporation into NASA's Crew Exploration Vehicle, and possible entry probes to fly on the Jupiter Icy Moons

Orbiter (JIMO) mission.

Nanoelectronics: Future Exploration missions will require modular, reconfigurable electronics with performance at least comparable to that which exists in ground processors today, yet able to perform in harsh space environments despite very severe limitations on spacecraft resources. Nanotechnology will enable this, and revolutionize electronics in this century much as the integrated circuit did in the last.

X-ray tube for X-ray Diffraction and Fluorescence: An X-ray tube using carbon nanotubes has been developed that is substantially smaller and 10 times lighter than commercial X-ray tubes. The new technology will transform the study of planetary surfaces; permit lightweight, low power mass spectrographs; and facilitate habitat purification.

Nano Chemical Sensor: Chemical sensors using carbon nanotubes (CNT) and other nanostructures have been developed to detect volatiles such as water, ammonia, NOx, CO2, and hydrocarbons, enabling the use of extremely sensitive, light, and compact sensors.

High Thermal Conductivity Material: New nanotube based materials have been developed that will radically improve heat dissipation of high-performance computers and high power optical components by factors of 2X.

New Composite Materials that May Enhance Pressure Vessels for Atmospheric Probes of the Gas Giants: Studies underway suggest that Titanium/Fullerene composites may improve the capability of pressure vessels for probes like that used for the Galileo Probe mission to Jupiter.

Putting it all together: It appears that nanotechnology may be a key to enabling nanoprobes ($1 \leq 10$ kg), helping realize planetary atmospheric scientists' desire for "multipile probes to multiple worlds"[1].

REFERENCE

1. J. O. Arnold[(1)] and E. Venkatapathy, *"Developments in Nanotechnology and Implications for Future Atmospheric Entry Probes.* International Workshop on Planetary Probe Atmospheric Entry and Descent Trajectory Analysis and Science, 6-9 October, 2003, Lisbon Portugal