HUMAN SPACE ENDEAVOURS SYMPOSIUM (B3)
New Technologies, Processes and Operating Modes Enabling Future Human Missions (7)

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EARLY FIRE DETECTION TECHNOLOGY FOR MANNED SPACECRAFT

Abstract

During the manned space missions, the crucial concerns of the spacecraft and the crew's safety require long term reliable, real-time and accurate smoke monitoring of the cabin atmosphere to provide early warning of a fire. However, the absence of the thermal buoyancy effects in the microgravity environment makes the smoke particle movement more random, thereby brings more difficulties to the smoke detection. The prior spacecraft smoke detectors include the UV-sensing fire detectors, the Brunswick Defense™ particle-ionization smoke detectors, and the Allied Signal light-scattering smoke detectors. The need of more reliable and accurate fire detection technology is strengthened by a number of reported incidents of false alarms or no alarms in space missions. In order to increase the detection reliability and reduce the response time, a novel early fire detection system for manned space missions, integrating the laser scattering smoke detection technology with the Near-IR laser Photoacoustic trace gas measurement technology, was introduced in this paper. Since the Photoacoustic sensor measures the acoustic pressure wave which is directly related to the absorbed energy by gas molecules and detected by second harmonic technology, it is immune to the background signal and easily achieves ppm level of detection limits. The concentration of carbon monoxide is very low at normal atmosphere, but dramatically increases in nearly all types of fire events, so it was selected as the target gas for the fire signature. In the proposed sensor, the Photoacoustic gas sensor consists of a 1.56 μm distribute feedback laser, the gas cell with particle filters, and the ultra-sensitive acoustic measurement unit with mechanical vibration isolation frame. Another part is the smoke detector, consisting of the laser diode as light source, the photodiode to sense forward scattered light, the labyrinth obscuration cell. The sample gas of both parts is sucked from the cabin air through a micropump, which can keep the system response time less than 2s, even in the microgravity environment. The experimental results of the prototype device show that the detection limit of carbon monoxide is 2ppm and attenuation sensitivity of the smoke is 0.5%/m with satisfying the detection requirements for space missions. The device is designed to reliably operate 5 years on orbit. With light

weight (1kg) and low power consumption (2W), the proposed system, combining the photoacoustic gas detection technology with the laser scattering smoke detection technique, is suitable for reliable early fire detection in manned spacecraft.