MITIGATION OF LUNAR DUST ON SOLAR PANELS AND OPTICAL ELEMENTS FOR LUNAR EXPLORATION UTILIZING ELECTROSTATIC TRAVELING-WAVE. H. Kawamoto[1], M. Uchiyama[1], B. L. Cooper[2] and D. S. McKay[3], [1]Dept. of Applied Mechanics and Aerospace Engineering, Waseda University, 3-4-1, Okubo, Shinjuku, Tokyo 169-8555, Japan, kawa@waseda.jp; [2]Oceaneering Space Systems, 16665 Space Center Blvd., Houston, TX 77058-2268; [3]Johnson Space Center, NASA, 2101 NASA Parkway, Houston, TX 77058.

Introduction: The lunar surface is covered by a layer of regolith (soil), and approximately 20% by volume of this material consists of particles less than 20 μm in diameter. Because of its small size and the low gravity, lunar dust is easily lofted when any disturbance occurs. The dust then covers solar panels and optical elements such as lenses and mirrors, causing degradation of their optical performance. To overcome this problem, we have developed a cleaning system that employs electrostatic traveling-waves for removing lunar dust. [1], [2]

System Configuration: The developed cleaner system is shown in Fig. 1. The conveyer consists of transparent ITO electrodes printed on a glass substrate. Traveling-wave propagation is achieved utilizing a set of positive and negative amplifiers controlled by a microcomputer. Four-phase rectangular voltage is applied to the electrodes because it is most efficient compared to sine or triangular waves. The power system is designed to be simple, small, and lightweight for space applications.

Results and Discussion: The following features have been clearly demonstrated:

(1) A simple power supply was developed for the cleaning system. Power consumption was as low as 0.06 Wh for cleaning an area of 1 m^2.

(2) More than 98% of the dust could be removed in vacuum as shown in Fig. 2. The transmission rate of light was reduced only a few percent when ultrasonic vibrations were used in conjunction with the traveling-waves. The amount of residual dust increased slightly over repeated tests; reducing a saturation level which did not seriously affect light transmission, as shown in Fig. 3.

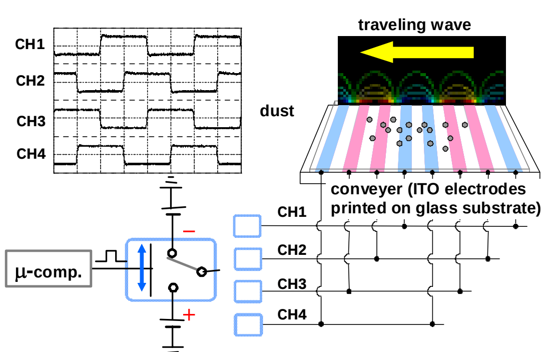

Figure 1: Electrostatic cleaning system.

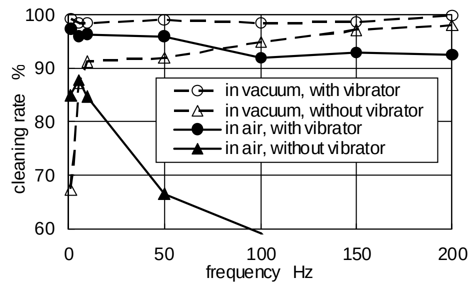

Figure 2: Performance of electrostatic cleaner.

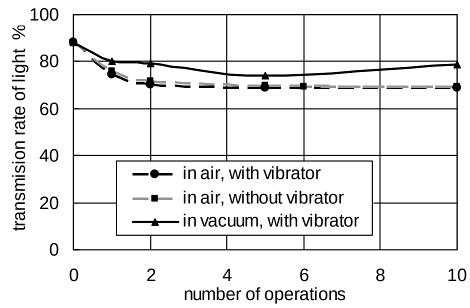

Figure 3: Decrease in averaged transmission rate of light due to increase in residual dust on conveyer.

(3) Both positively and negatively charged dust particles (as well as electrically neutral particles) could be cleaned without changing the system configuration.

(4) From the results of a numerical investigation based on a 3D distinct element method, it is predicted that the performance of the system will improve in the low-gravity environment on the Moon.

(5) On the basis of these investigations, we have successfully demonstrated the removal of actual lunar dust returned by the Apollo 11 lunar surface mission. It was easier to remove actual lunar dust than the widely used simulant JSC-1A. Cleaning performance of the system is expected to further improve in the low-gravity environment of the Moon. Evaluation with simulants on the Earth is a conservative approach.

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References: [1] Kawamoto H, Seki K and Kuromiya N. (2006) J. Phys. D: Appl. Phys., 39, 1249-1256. [2] Kawamoto H and Uchiyama M. (2008) LEAG-ICEUM-SRR, 72.