Development of the bread board model of the Life-signature Detection Microscope (LDM)

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Present Mars is hostile to life, but recent findings tend to support the possible presence of microbes near the Mars surface. MSL Curiosity has found organic compounds [1], the temporal increase of methane concentration in the Martian atmosphere [2], and reduced sulfur compounds such as pyrite in Martian soil [3]. Methane and reduced sulfur compounds can be energy sources to support the growth of chemoautotrophic microbes [4]. The detection of hydrated salts at Recurring Slope Lineae suggested the possible presence of liquid water [5]. Since UV radiation, which is harmful to life, would be shielded by thin layers (less than a millimeter) of dust or regolith [6], microbes could survive under a depth of several centimeters from the surface. Although the Viking mission in the 1970s did not find evidence for life on the Mars surface [7], the sensitivity of the GC-MS (mass spectrometer) was found not to be very high. It was not able to detect 10^6 microbial cells in 1 gram soil [8, 9], indicating that another life detection program is necessary.

The Life-signature Detection Microscope (LDM), which we have proposed [10], has the potential sensitivity much higher than the Viking instrument. The LDM is based on fluorescent microscopy and detects organic compounds, membrane structures, and catalytic activities stained by fluorescent pigments. This technique is especially useful for the detection of living microbes. It has the potential to visualize a single cell in micron scale. LDM scans about 1 mm^3 and detects less than 10^4 cells in 1 gram regolith, which is comparable to the least populated area of the terrestrial environment, such as the Atacama desert in Chile. If microbes are not detected, we can determine the upper limit of the microbial density, which is useful information to evaluate the risk of human contact with Martian microbes in future manned explorations.

We have developed the bread board model (BBM) of LDM which is composed of 4 parts: a sample chamber, a light source, a microscope, and a CMOS image sensor. The sample chamber has a sample unit which has a sample holder, 2 pigment solution tanks, a filter unit for concentrating cells. By moving the sample chamber, 1 mm^3 of the bottom of the sample holder and a filter unit are photographed by the image sensor through the microscope. The BBM successfully detected and visualized bacteria added in a Mars simulant, MGS-1, at a density of 10^4 cells g^{-1}.

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