PATTERNED SUBSTRATES FOR THE PHOENIX MICROSCOPY STATION. Sykulska H., Vijendran S., Pike W. T., Optical and Semiconductor Devices Group, Department of Electrical Engineering, Imperial College of Science, Technology and Medicine, London, UK

Introduction: The aim of this work is to understand how Martian analog soils and dust adhere to substrates of different materials and topography. The Phoenix MECA package includes a microscopy station with an optical microscope and an atomic force microscope (AFM) [1]. Samples of the Martian soil and dust will be transferred into the spacecraft from the robotic arm to the microscopes via individual substrates. The design of these substrates are crucial for preparing the samples for microscopy, especially for the AFM which has a very limited field of view and height range. In addition, the AFM and substrates are mounted vertically, so good adhesion of the particles to the substrates will be critical.

Experiment: Scanning Electron Microscopy (SEM) and AFM have been performed with various analogs on substrates with a range of topographies including regular patterns of pits and pillars. We have shown that flat silicon or metallic substrates cannot be relied upon to hold all the particles that are of interest for analysis by the optical and atomic force microscopes. Custom-designed substrates with appropriate materials will be required for adequate sample preparation. Figure 1 shows an example distribution of sizes of particles (from a sample of JSC Mars-1) that adhere merely by short range forces to a flat silicon substrate in a vertical position. Results show that particles with diameters greater than 150 µm are unlikely to adhere to a flat substrate in the vertical orientation.

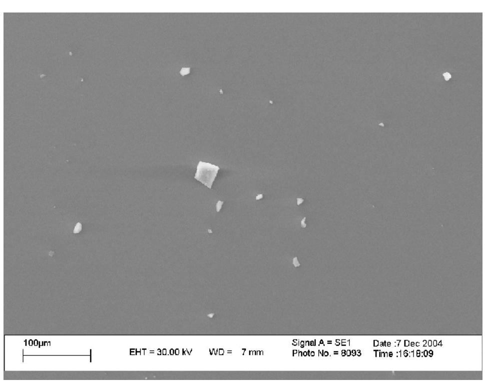

Figure 1: SEM of a flat silicon substrate with particles from a dry sample of JSC-Mars 1. A small pile of dry soil was placed on the dry substrate which was then orientated vertically, removing most of the particles except those adhering by Van der Waals or electrostatic forces.

Additionally, to successfully scan small particles with the AFM, the particles need to be fixed well to the substrate to avoid movement by the AFM tip. This was a performance limiting issue that was identified during the AFM development program for the canceled 2001 Mars Surveyor Lander mission. Quartz particles less than 5 µm in diameter were found to be pushed by the scanning AFM tip even in dynamic mode operation if scan speeds higher than 10 µm/s were used [2]. To mitigate this problem, we have fabricated deep reactive ion etched (DRIE) patterns of pits and pillars in silicon to trap particles for AFM analysis. Figure 2 shows an AFM image of a DRIE Si substrate with a grid of 5 µm diameter pits and a sparse coating of diatomaceous earth. Figure 3 below shows an SEM micrograph of the same region.

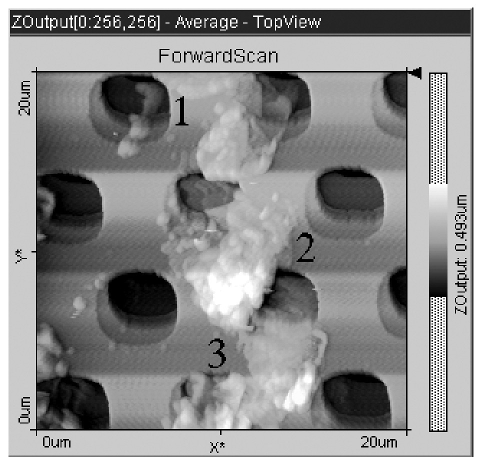

Figure 2: AFM topography image of an etched Si substrate with 5 micron pits and particles of diatomaceous earth. The numbers correspond to the same locations in Figure 3 below.

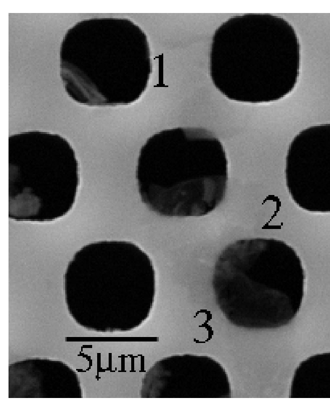

Figure 3: SEM micrograph of the same region shown in Figure 2. The SiO_2 particles of the diatomaceous earth are barely visible compared to the easily discernible topography in the AFM image.

Substrates with high aspect ratio topography have demonstrated that particle adhesion can be increased using these features. Particles isolated and lodged within pits or gaps between pillars should allow more rapid scanning of images by the AFM without the distortion produced by lateral movement of the particles. A reduction of the time taken to acquire images will in turn translate into more useful data returned by the microscopy station when it explores the northern plains of Mars in 2008.

All the evidence to date indicate that sample preparation will be crucial if useful scientific data is be obtained from the AFM. It seems certain that some form of patterned substrates will be required to enable the successful operation of the AFM on MARS. Tests will continue with a range of different patterns to determine which ones are best at sorting and holding the particles of interest.

References:

[1] http://mpfwww.jpl.nasa.gov/2001/lander/meca/micro1.htm

[2] S. Gautsch *et al., (*2002) Surf. Interface Anal. **33**, pp163-167