Space weathering: Surface gardening processes on Mercury's surface. A. N. Stojic[1], S. G. Pavlov[2], A. Morlok[1], H. Hiesinger[1] and M. Sohn[3], [1]Institut fuer Planetologie, Westfälische Wilhelms-Universität Münster, Wilhelm-Klemm Str. 10, 48149 Muenster, a.stojic@uni-muenster.de, [2]Deutsches Zentrum fuer Luft-und Raumfahrt (DLR), Institute of Optical Sensor Systems, Rutherfordstraße 2, 12489 Berlin, sergeij.pavlov@dlr.de, [3]Hochschule Emden/Leer, Constantiaplatz 4, 26723 Emden, Germany

Introduction: Space weathering is a term which covers a wide range of various processes changing the surface of planetary bodies with only tenuous exospheres over a given time period. Cosmic rays, solar wind, and micrometeorite impacts are some of these destructive processes, which alter a celestial surface not only topographically but also chemically [1] and thus can significantly change the body's optical and spectral characteristics. Due to the lack of a substantial atmosphere, surfaces of such bodies are exposed to these processes to a far greater extent than other planetary bodies with a protective envelope and a strong magnetic field, e.g., our Earth [2,3]. The reprocessing of planetary regolith by micrometeorites can cause a significant surface change not only due to grain fragmentation and formation of agglutinates but also by creating a micro-plasma environment while impacting the surface [4-6]. These changes do not only affect the impacted area, they also affect the immediate regolith neighborhood to varying degrees. In order to investigate changes at the impact site as well as the surrounding material, we conducted several experiments on which we report in this study.

Experimental: Synthetically grown forsterite single crystals (Czochralski method) were ground to a powder with grain sizes varying between 60 and 120 µm. We obtained loosely pressed pellets by pressing the powder for 10 minutes at a pressure of 4 t cm^{-2}. We used a ns-pulsed Nd:YAG laser, part of the laser induced plasma spectrometer (LIBS) at the DLR Berlin to simulate the effects of hypervelocity micrometeorite impacts on planetary surface analog material. Using the LIBS allowed for a simultaneous chemical analysis of the generated plasma. Spectra of the ablated sample material were acquired by the VIS-IR spectrometer (Laser Technik Berlin) revealing its elemental composition. The generated plasma precipitated on a silicon wafer and was also caught in-situ on TEM films. The TEM films (5 pieces) were arranged in the chamber in such a way that questions about a preferred precipitation site (is there any precipitate on the ground?) could be assessed subsequently. The pellet surface was irradiated with a Nd:YAG laser operated at 1064 nm and 10 Hz. Diffuse reflectance spectra in the mid-IR range (7µm – 14 µm) were obtained from the impact sites of the pellet surface (Fig.1) using a Bruker Hyperion 2000 system coupled to the external port of the Bruker Vertex 70v at the Hochschule Emden/Leer. We used an aperture of (250 x 250) $µm^2$ and performed 512 scans on each spot to reduce the background noise.

Figure 1: Target pellet of forsterite (synth.) colored numbers correspond to spectra of the same color in Fig. 2.

Transmission electron microscopy (HRTEM, BF/DF TEM) analyses of several selected nanoparticles were conducted using the TEM Zeiss Libra (200kV) at the University of Münster.

Results & Discussion: *IR spectral analyses:* Comparison of IR spectra (Fig.2) obtained from different sites of the irradiated pellet shows that only little effects of the destructive impacts are visible in the IR spectrum.

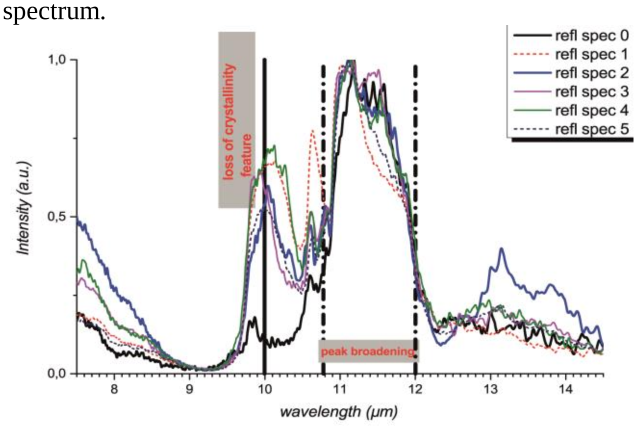

Figure 2: Normalized diffuse reflectance spectra of selected pellet sites of crystalline forsterite (colors correspond to numbered sites in Fig.1)

The various peak intensities at 10 µm together with a broadening of peaks between 11 µm and 12 µm are indicative of a decreasing crystallinity (most prominently seen in Fig. 2 spec #0) [7]. Dashed lines represent spectra from pellet parts which were not irradiated by the laser (Fig.2. #1 and #5). They preserved their crystalline spectral characteristics although their intensities are slightly decreased when compared to other spectra, which were obtained from the trench crater (e.g. spec #4). This could be attributed to amorphous ejecta material, which now covers the crystalline surface. We do not see a consistent trend of decreasing crystallinity within the trench. Some sites of the pellet clearly show a starting amorphisation (loss of peak at 10 µm in spec #0) whereas spectra #2, #3 and #4 retain their crystalline peak at 10 µm but show a broadening of the peak between 11 µm and 12 µm.

TEM analysis of plasma precipitate: Bright Field (BF) and Dark field (DF) analyses of the TEM films showed that the plasma resublimated on the amorphous carbon support film as little spheres, ranging between 50 nm and 150 nm (Fig.3a and b).

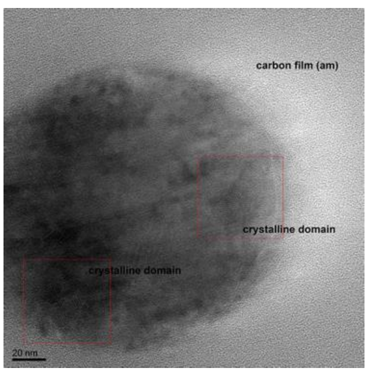

Figure 3a: BF-TEM micrograph showing an amorphous sphere with crystalline domains (red boxed areas contain lattice fringes).

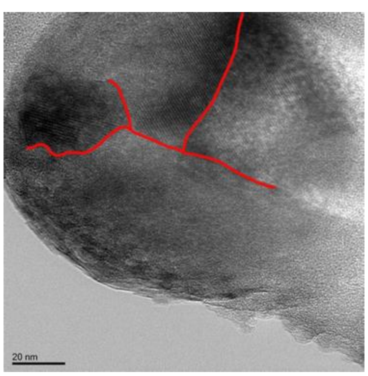

Figure 3b: Red lines denote grain boundaries between little crystallites (BF-TEM).

We have not observed a preferred precipitation site within the chamber arrangement. Plasma precipitates (nanospheres) were observed in same proportions on TEM films directly placed within the plasma propagation direction and on those films put on the floor of the set-up chamber. A difference was only seen in the amount of ballistically ejected material, which was clearly higher on those films placed on the ground. High Resolution (HR) TEM studies indicate that most spheres show either fully recrystallized or partially crystalline domains. In the case of almost fully recrystallized nanospheres, several crystalline individuals (red outline Fig. 3b) separate the sphere in distinct segments. Those nanospheres exhibiting only partially crystalline domains, presumably resublimated on the carbon support film in an amorphous metastable state initially, as this scenario is more favored by thermodynamical considerations. Presumably, beam irradiation caused by the incident e^- beam (TEM) triggered the recrystallisation. Processes observed on the TEM films, i.e., precipitation of an initially amorphous silicate rich layer and subsequent crystallization triggered by irradiation can take place on the surface of Mercury. Small amounts of precipitate can build up layers of newly formed "recycled" material on neighboring regolith grains and thus change the spectral appearance of a surface over time significantly. The precipitated layers can either recrystallize being exposed to irradiation or crystalline regolith grains can act as crystallisation seeds (lattice fringes of silicates are very similar) and could therefore favor an immediate crystallisation upon precipitation. In any case, the change of regolith either by gradual amorphisation or the precipitation of newly formed minerals over time could give rise to a significant change in Mercury's IR spectral appearance.

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