Laboratory emission spectra at 500°C at the Planetary Emissivity Laboratory at DLR in Berlin - Challenges, challenges and even more challenges. J. Helbert[1] and A. Maturilli[1], [1]Institute for Planetary Research, DLR, Rutherfordstr. 2, 12489 Berlin, Germany, joern.helbert@dlr.de.

Introduction: The Planetary Emissivity Laboratory at DLR in Berlin has a long standing expertise in providing spectral data of planetary analog materials [1,2,3]. Based on this experience we decided 4 years ago to extend our laboratory capabilities to support mission to Venus and Mercury. Both planets exhibit surface temperatures up to 500°C and this extreme temperature range affects the spectral characteristics of the surface minerals. First test data obtained in support of the NASA MESSENGER misson to Mercury [4, 5] highlighted the need for high temperature measurements. The measurments will help to obtain meaningful interpretation of the remote sensing data not only from MESSENGER but also from VenusExpress, BepiColombo and Spitzer to name only a few.

Here we are reporting about the challenges encountered in the last 4 years and our approach to mitigate them.

The laboratory setup The PEL is equipped with a Bruker Vertex 80V instrument, coupled to an evacuable high temperatures emissivity. Figure 1 shows the high temperature setup in the PEL.

The new generation Bruker VERTEX 80V FTIR spectrometer has a very high spectral resolution (better then 0.2 cm-1), and a resolving power of better than 300,000:1, and can be operated under vacuum conditions to remove atmospheric features from the spectra. To cover the entire from 1 to 100 µm spectral range, two detectors, a liquid nitrogen cooled MTC (1-16 µm) and a room temperature DTGS (15-100 µm) and two beamsplitter, a KBr and a Mylar Multilayer, are used. However, the system DTGS+Multilayer is usually operated under its full capability, since it allows to measure spectra until 300 µm.

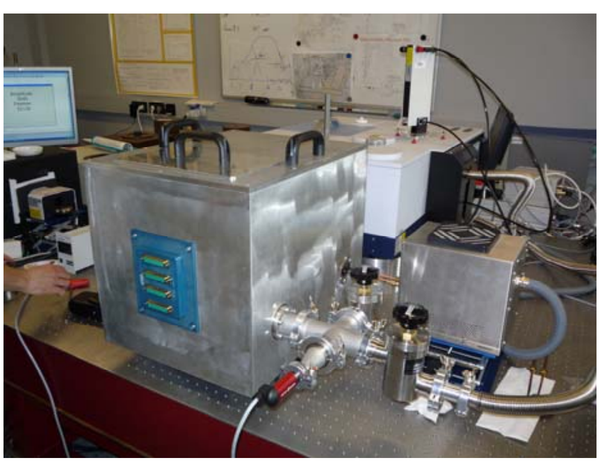

Figure 1: The PEL set-up at DLR, Berlin

The spectrometer is coupled to our newly completed planetary simulation chamber (see Figure 2), that can be evacuated so that the full optical path from the sample to the detector is free of any influence by atmospheric gases. The chamber has an automatic sample transport system which allows maintaining the vacuum while changing the samples.

Figure 2: The planetary simulation chamber (top cover was removed)

The heating: The main challenges was heating the samples to temperatures of 500°C. Here we used an innovative approach. The samples are placed in a stainless steel sample cup which is heated by a 1.5kW induction system. The induction heating system that is permanently installed in the new chamber allows heating the samples to temperatures of up to 700K permitting measurements under realistic conditions for the surface of Mercury. The chamber can be even used as an independent vacuum-oven, where to thermally shock minerals to be furtherly measured in reflectance.

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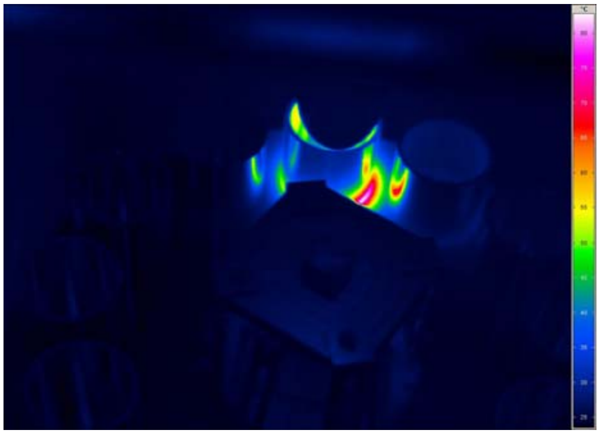

Figure 3: Thermal image showing the heated sample cup and the cool chamber interior

Thermal stress: The temperature difference between the cup and the cool chamber puts materials under significant stress. Figure 4 shows our first sample holder made from a glass ceramic. The thermal stress induced during test measurments introduce fractures which eventually lead to cracking of the plate.

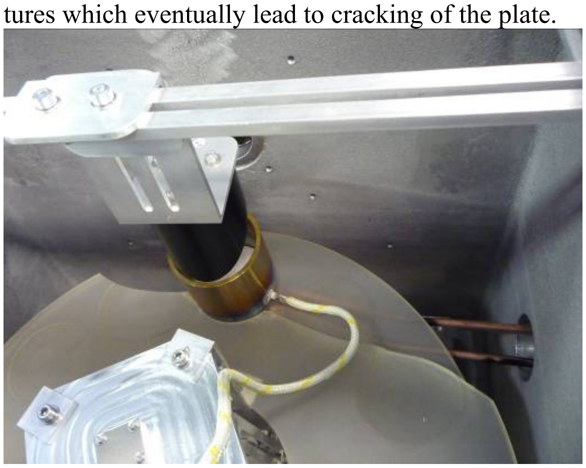

Figure 4: First sample holder broken after heating sample to 600°C

Calibrating: In order to obtain emissivity measurements one has to measure a black body of known emissivity that does not change with temperature. While this is a relatively easy task for temperature up to 200°C it becomes a real changes beyond 300°C.

The first task is to find a coating that survives temperatures beyond 500°C in a vacuum environement without degradation. We contacted a large number of suppliers and test over the course of the years a large number of materials. Figure 5 shows the example of a blackbody coating that showed significant degradation at 500°C

Figure 5: Black body coating partially degraded after heating to 500°C

Temperature measurement: Obtaining realiable sample temperatures is another major challenge. The challenge here is already to find a temperature sensor that survives heating to 500°C and beyond without degradation. We are currently using thermal couples glued into the cups with a special high temperature ceramic as seen in Figure 6.

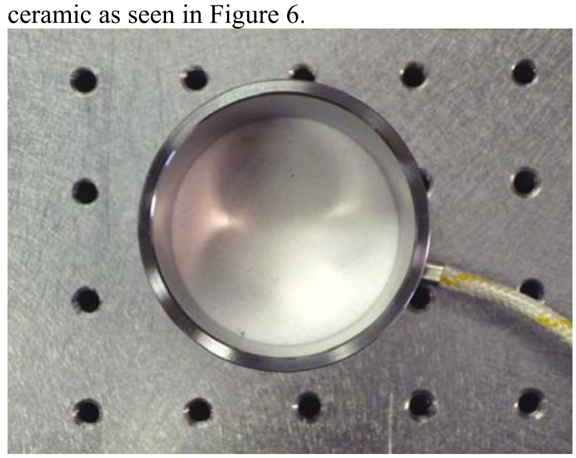

Figure 6: Sample cup with glued thermocouple

Challenges, challenges and even more challenges: This abstract provides only some of the examples of the challenges we faced. We will discuss how we are dealing with each of these challenges and many other not shown here.

References: [1] A. Maturilli, J. Helbert et al. (2006), *PSS 54*, 1057–1064. [2] A. Maturilli, J. Helbert, et al. (2008), *PSS 56*, 420–425. [3] A. Maturilli and J. Helbert, this meeting [4] Helbert, J. and Maturilli, A. (2009), *EPSL 285*, 347–354. [5] D'Amore, Helbert, et al. (2011), *This conference*.