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Measuring the thermal conductivity of porous media under low atmospheric pressures

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Upcoming and planned space missions will carry experiments to measure the thermophysical properties of cometary and planetary materials. In order to evaluate and interpret these measurements, reliable laboratory data for the thermal conductivity of porous and granular media under low atmospheric pressure conditions need to be collected. The low thermal conductivity of these materials (∼0.1 to 0.001 W/mK) and the large contact resistance between the material and any thermal conductivity sensor makes these measurements extremely challenging. In order to obtain reliable results, a material exchange project involving several laboratories (DLR, Austrian Academy of Science, open for further participation) has been initiated. All labs will carry out thermal conductivity measurements on identical specimen under defined conditions and results will then be compared to gain confidence in the obtained results. At DLR, thermal conductivity measurements will be carried out using the Transient Hot Strip (THS) method, as transient methods suffer less from contact resistance problems than steady state methods such as, e.g., the Guarded Hot Plate method. The employed THS heater/sensor consists of a thin Ni-Fe circuit on a Kapton base layer and is energized with a constant power to determine the self-heating curve as a function of time, which can then be inverted to give the thermal conductivity and diffusivity of the ambient medium. The applied sensor layout minimizes axial heat losses and small diameter (low thermal conductance) electrical connections to the measurement electronics are applied. Furthermore, the thin-film Ni-Fe circuit and Kapton foil ensure a low thermal capacity of the setup. First results using this setup and the certified fibre-glass reference material IRMM440, which has a thermal conductivity of 0.032 W/m, indicate that this method is capable of measuring even low thermal conductivities with an accuracy of 11% and a precision of 1.5%. The method can probably be improved by optimizing the length to width ratio of the sensor and applying a detailed numerical model for the data inversion. Once the method has been fully established, measurements will be extended to glass beads under low atmospheric pressure conditions.