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Melting and subsolidus phase relations of Fe-Si-S alloys at Mercury's core conditions

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The internal structure of Mercury holds key information regarding the planet's formation and its peculiar magnetic field. Waiting for incoming observations by BepiColombo, current knowledge of the interior structure of Mercury relies primarily on geodetic and surface chemistry data collected by MESSENGER. Results from spectral and compositional analysis supplemented by cosmochemical evidence indicate that light elements such as S, and Si are most likely alloyed to Fe in Mercury's core. This notion is further supported by the very reducing redox conditions (from -2.6 to -7.3 log units below Fe-FeO oxygen buffer) predicted to occur during the planet's differentiation that argue for significant quantities of Si and S partitioned into metallic iron. Thus, it is of primary importance to determine the Fe-Si-S phase diagram and to understand the high pressure and high temperature properties and thermodynamic behavior of Fe-Si-S alloys at conditions directly relevant for Mercury's core. Very recently the binary Fe-FeSi phase diagram has been established at Mercury's core conditions, but phase and melting relations in the Fe-Si-S ternary system still are poorly constrained, in particular at the relatively low pressures and temperatures relevant for Mercury's core.

To address this issue, we performed angular dispersive powder X-ray diffraction experiments in laser-heated diamond anvil cells on selected composition in the Fe-Si-S system (i.e., Fe-4S-6Si, Fe-16S-6Si, Fe-4S-12Si, and Fe-16S-12Si, all in wt. %) at the P02.2 Extreme Conditions beamline at DESY Synchrotron facility (Germany). For all compositions, eutectic melting and subsolidus phase relations were investigated up to about 45 GPa. Ex situ chemical analysis of the recovered run products were performed at the IMPMC laboratory on the extracted FIB thin sections cut throughout the heated spots.

Here we will present preliminary results on the eutectic melting and Fe-Si-S phase relations as a function of pressure, temperature and composition, with specific focus to the conditions expected within the core of Mercury.