EXPERIMENTAL STUDY OF SULFIDATION OF METALLIC IRON UNDER PROTOPLANETARY DISK CONDITIONS

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Introduction: Sulfur is a major volatile element in the solar system, and it shows various degrees of depletion in chondrites reflecting fractionation of volatile elements between solids and gas in the early solar system. Elemental fractionation of volatile elements may be attributed to incomplete condensation of volatiles into solids due to dispersal of disk gas. In order to discuss incomplete condensation of volatiles, it is of much importance to understand kinetics of volatile condensation, i.e., sulfidation kinetics of metallic iron in case of sulfur. Experimental studies on sulfidation of metallic iron and alloy have been carried out in order to investigate sulfidation behavior in the early solar system [1-3]. However, there has been no sulfidation experiment performed under low-pressure plausible disk conditions.

Experiments: In order to investigate kinetics of sulfidation of Fe metal under protoplanetary disk conditions, sulfidation experiments of metallic iron were performed at low pressures using a vacuum gold furnace. The heating unit of the furnace consists of a resistance metal heater and a surrounding gold mirror tube that reflects infrared light from the heater effectively to heat a sample in the chamber. The vacuum chamber of the furnace, connected to a turbo-molecular pump, is made of a silica glass tube, which makes it possible to introduce a reactive gas such as H_2S and H_2 in the chamber.

A chip of metallic iron (3.0 x 3.0 x 0.5 mm) was placed in a silica-glass sample holder and heated at 1070 K for 5 hours in hydrogen gas (~1 Pa) in order to clean the surface of the chip. The chip was then heated at 770 K for 24-132 hours in a mixture of He and H_2S, of which S/He ratio was set at the solar value at 1 Pa. The run products were examined with FE-SEM (JSM 7000F) and EDS.

Results and Discussion: Sub-μm-sized iron sulfides nucleated sporadically on the surface of metallic iron (~20 grains in 400 μm^2 area) after 24-hour reaction with H_2S-He gas. On the chip reacted for ~60 hours, 1-μm iron sulfide grains were found (~10 grains in 400 μm^2 area), which seem to have grown after nucleation, as well as sub-μm-sized newly nucleated grains. Elongated sulfide grains (~3-5 μm in length), of which direction of elongation seems to be controlled by the crystallographic orientation of metallic iron, were found on the chip reacted for ~130 hours. Rounded ~1-μm grains and sub-μm grains were also found on the chip reacted for ~130 hours, but the abundance of sulfides was not enough to cover the entire surface of the chip.

These results indicates that observed sulfidation behavior appears to be more sluggish than those observed in previous experiments done at one atmosphere total pressure [e.g., 1]. Sulfidation observed in this study appeared to be controlled by nucleation and subsequent growth of iron sulfides. Details of kinetics of nucleation and growth of iron sulfide, which will be applicable to sulfidation of metallic iron in protoplanetary disks, will be discussed at the meeting.

References: [1] Lauretta D. S. et al. 1996 *Icarus* 122:288-315. [2] Lauretta D. S. 2005 *Oxid. Metals* 64:1-22. [3] Schrader D. L. and Lauretta D. S. 2010 *GCA* 74:1719-1733.