# Cooling experiments of Fe-FeS melt: A cooling speedometer of chondrules

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Although chondrules are the main constitutes of chondrites, their formation mechanism has not been fully understood. In order to understand the chondrule forming processes, the thermal history of chondrules should be constrained. In particular, the complete thermal history at subsolidus temperature has not been constrained and should be as it can provide important information on the formation environment [e.g., 1, 2]. Here we focus on the eutectic solidification texture of Fe-FeS melt to develop a cooling speedometer for chondrules at temperatures below 1000°C.

Mixed powder of Fe metal and FeS with a nearly eutectic composition were heated in an evacuated sealed silica tube with graphite, and rapidly quenched in water. The quenched sample was crushed into 50-300 $\mu$m-sized particles to be used as a starting material. The particles were dispersed in silica wool and sealed in silica glass tubes in vacuum with graphite and a mm-sized FeS grain to keep a reducing condition and to suppress evaporation of sulfur from the starting material. The sealed glass tube was heated at 1330°C for 3 hours and cooled down to ~300°C at different cooling rates of 25, 100, 500, and ~$10^4$ K/h (quenched in air).

All Fe-FeS particles contained Fe metals grains embedded in a FeS matrix. The size distribution of metal grains changed with cooling rates. Metal grains were larger in the samples cooled at slower rates. The typical size of metal grains was 1-2 $\mu$m for the cooling rates of 25 and 100 K/h, while smaller than 1$\mu$m for cooling rates higher than 500 K/h.

The size distribution of metal grains in the experimental products was compared to Fe-FeS eutectic-like textures observed in chondrule opaque assemblages in CR chondrites. We found that there are chondrules cooled at a rate faster than 500 K/h. We discuss the cooling history of chondrules from high to low temperatures (below the silicate solidus) and compare to contraints derived from silicate textures.

[1] Schrader D. L. et al. (2016) *47th LPSC*, #1180.
[2] Connolly and Desch (2004) *Chemie der Erde* **64**, 95.