Deintercalation of excess iron via an electrochemical method for FeTe$_{0.8}$S$_{0.2}$

A. Yamashita$^{*,1,2}$, S. Demura$^1$, T. Yamaki$^1$, H. Hara$^1$, K. Deguchi$^1$, S. J. Denholme$^1$, H. Okazaki$^1$, M. Fujioka$^1$, T. Yamaguchi$^1$, H. Takeya$^1$, and Y. Takano$^1$

$^1$ National Institute for Materials Science, Japan
$^2$ Kochi University of Technology, Japan

E-mail address: YAMASHITA.Aichi@nims.go.jp

Iron chalcogenide superconductors (11 system) have the simplest crystal structure among iron-based superconductors, as they are composed of only superconducting layers. It is well known that excess iron with a valence value of 2+ exists between the layers, and suppresses superconductivity via charge doping [1]. We have succeeded in deintercalating the excess iron by the use of alcoholic beverage annealing [2]. This is a result of the chelate effect, which originates in the organic acid which forms part of the alcoholic beverages. In regards to alcoholic beverage annealing, we expected to be able to deintercalate excess iron in a shorter time by using an electrochemical reaction with a solution of organic acid.

Polycrystalline samples of FeTe$_{0.8}$S$_{0.2}$ were synthesized by a solid-state reaction using powders of Fe, Te, and S. The samples were sealed in an evacuated quartz tube, and sintered at 600 °C for 10 h. Obtained samples were ground, pelletized, and sintered again in an evacuated quartz tube under the same conditions. For the electrochemical reaction, a solution of dissolved 6 g/L of citric acid with ultra pure water was prepared. To characterize the crystal structure of samples, X-ray diffraction (XRD) measurements were performed. The magnetic susceptibility for each sample was also measured by SQUID magnetometer.

The as-grown sample does not show superconductivity. The shielding volume fraction of the samples treated electrochemically for 1 hour increases with increasing applied voltage from 0 V to 1.5 V. Above 1.7 V, it suddenly decreases. Therefore, we have demonstrated that an electrochemical method using citric acid as solution is more effective to deintercalate a large amount of excess iron than the alcoholic beverage annealing. By using this method, it is possible to induce superconductivity in other layered compounds which have excess iron.

References