The possible existence of neutral atomic hydrogen in interstitial voids of silicates inferred from muon spin rotation spectroscopy

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Hydrogen in silicates has been thought to exist as a hydroxyl group. However, recent experimental and theoretical studies have revealed that small molecules, such as H_2 and He, can dissolve into interstitial voids of silica glass and cristobalite [1-3]. Moreover, in the field of applied physics, muon-spin-rotation spectroscopy (μSR) and other methods, which probe hydrogen more directly, have long suggested that hydrogen may exist in silica layer of metal-oxide-semiconductor devices [4,5].

We have conducted μSR experiments on silica glass, densified silica glass, quartz, coecite, stishovite, forsterite, bridgmanite, etc. Positive muon, which can be considered as a light isotope of proton, implanted in these samples was found to capture electron to form muonium, which corresponds to neutral atomic hydrogen. In stishovite, the hyperfine-coupling parameter and relaxation rate of spin polarization of muonium were measured to be very large, suggesting that muonium is squeezed in small and anisotropic interstitial voids without binding to silicon or oxygen [6]. These results imply that neutral atomic hydrogen may exist even in small interstitial voids of high-pressure silicates.

So far, it is difficult to conduct high-pressure in-situ μSR experiments, because a large amount of sample is necessary. We hope ultraslow-muon-microscope techniques at J-PARC open up an opportunity for in-situ experiments under the condition of earth and planetary interiors.

[1] Sato, Funamori, Yagi (2011) *Nature Commun.* **2**, 345.
[2] Efimchenko *et al.* (2013) *J. Phys. Chem. B* **117**, 422-425.
[3] Matsui, Sato, Funamori (2014) *Am. Mineral.* **99**, 184-189.
[4] Myasishcheva et al. (1968) *Sov. Phys. JETP* **26**, 298-301.
[5] Isoya *et al.* (1983) *J. Phys. Chem. Solids* **44**, 335-343.
[6] Funamori *et al.* (2015) *Sci. Rep.* **5**, 8437.