Relation of structure and superconductivity in iron-based superconductor: New findings on pressure response

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Iron-based superconductors are a new family of high critical-temperature (T_c) superconductors, following copper oxides, among which LaFeAsO is the first high-T_c iron-based superconductor. There are two ways to raise the T_c. In the electron doped $LaFeAsO_{1-x}H(F)_x$ (x = 0.2) (T_c = 18 K), the ion substitution from La to Sm rises to T_c = 55 K. In addition, the applying pressure to the crystal gives rise to T_c = 52 K under 6 GPa [1]. Their values are the highest class T_c among the bulk iron-based superconductors. Here, in order to investigate the origin of the latter large pressure-effect, we performed synchrotron X-ray diffraction experiments under pressure at Photon Factory [2].

Figure 1 (a) illustrates the resultant structural parameters of the Fe-As bond length and the As-Fe-As bond angle under pressure for $LaFeAsO_{1-x}H_x$. The parameters are deemed to be closely related to T_c. The T_c for each structure is also represented by the color map, and the red color indicates the higher T_c. The observation implies that the $FeAs_4$ coordination deviates from the regular tetrahedron or the As atomic heights 1.38 Å. This breaks a widely accepted structural guide. Since the T_c rising law is well explained by the theory originating from the spin density wave (SDW), the properties under pressure cannot be explained by SDW model. Figure 1 (b) shows the pressure response on the parent phases. The second parent phase is pressure-sensitive that disappears under 1.5 GPa, whereas the first parent phase exists up to high pressure [2]. This suggests that the origins of both parent phases differ and that the second parent phase is considered to be important for the high-T_c. The origin of the first parent phase is regarded as SDW, while the second parent phase recently comes from a strong electron correlation. Thus, we suggests that the electron correlation is more significant for the pressure induced high-T_c states in the present compound that have not been sufficiently discussed.

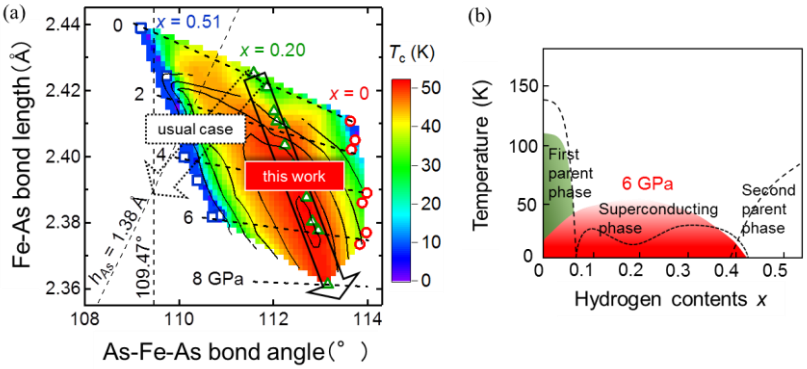

Fig.1. (a) Structural parameters and T_c for $LaFeAsO_{1-x}H_x$, (b) First and second parent phases, and superconducting phases.

References

[1] H. Takahashi et al., Sci. Rep. **5**, 7829 (2015).
[2] K. Kobayashi et al., Sci. Rep. **6**, 39646 (2016).