Highlight #1: SYNTHESIS of QUANTUM MATERIALS

Discovery of a novel superconducting iron-based silicide: LaFeSiO1-δ

Below a critical temperature called Tc, some materials become superconducting, transporting charge carriers without dissipation and expelling external magnetic fields. A lot of different superconductor families exist and among them the iron-based superconductors (IBS), discovered in 2008, constitute the family with the second highest Tc at normal pressure, next to copper oxides. But, such Fe-based compounds contain quite toxic elements like arsenic or selenium. In the last years new IBS were discovered with silicon or germanium in substitution of As/Se. Here we present a new member of the Fe-based silicide family, $LaFeSiO_{1-\delta}$, which is also found to be superconducting.

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Since their discovery in 2008, iron-based superconducting pnictides (As, P…) and chalocgenides (Te, Se…) are now a well-established class of unconventional superconductors, spanning multiple structural families, with Tc up to 55 K in bulk materials. This category of superconductors has recently been extended to other layered materials where pnictogen/chalcogen atoms are replaced by crystallogen elements (*i.e.* belonging to the carbon group: C, Si, Ge…): either with Ge in YFe_2Ge_2 (T_c ~ 2 K) or Si in LaFeSiH (T_c ~ 10 K).

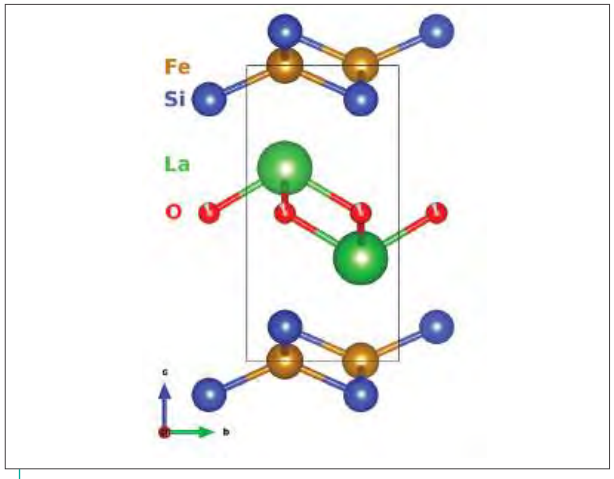

Fig. 1: *Crystal structure of the novel layered iron oxy-silicide LaFeSiO1-δ*

In this work, we present the discovery of a new compound obtained by topochemical oxygenation of LaFeSi. Such topotactic reaction allows the insertion of oxygen atoms between the double layer of La atoms, at the empty tetrahedral La_4 sites, preserving the remaining crystal structure. The properties of the resulting and unexpected crystallogenide, $LaFeSiO_{1-\delta}$ were probed by combining complementary experimental techniques: X-ray-, neutron- and electron diffraction, energy dispersive X-ray and nuclear magnetic resonance (NMR) spectroscopy, thermogravimetric analysis, resistivity and magnetization measurements. Our detailed study reveals that this crystallogenide is superconducting with a relatively high T_c ~ 10 K, despite its strongly squeezed Fe Si anion height, below 1 Å, challenging the usual relationship between crystallographic features and superconductivity in Fe-based compounds.

This unique crystal structure has a strong impact on the electronic properties of $LaFeSiO_{1-\delta}$. Just above T_c, resistivity shows a non Fermi liquid temperature scaling, *i.e.* a deviation from the T^2 temperature dependence, a signature of enhanced electronic correlations. This correlated behavior is also visible in the NMR data which evidences weak antiferromagnetic fluctuations. The calculated electronic structure of LaFeSiO is significantly changed compared to the one of the canonical LaFeAsO oxy-arsenide. In the oxy-silicide, the Fe related Fermi surface, consisting almost uniquely of hole pockets, suggests another kind of electronic correlations and then a different related superconducting mechanism than the usual s±-mechanism. Finally, the location of $LaFeSiO_{1-\delta}$, LaFeSiH and partially fluorinated $LaFeSiF_x$ superconductors in the phase diagram points towards the existence of a new emerging superconducting dome related to Fe silicides.

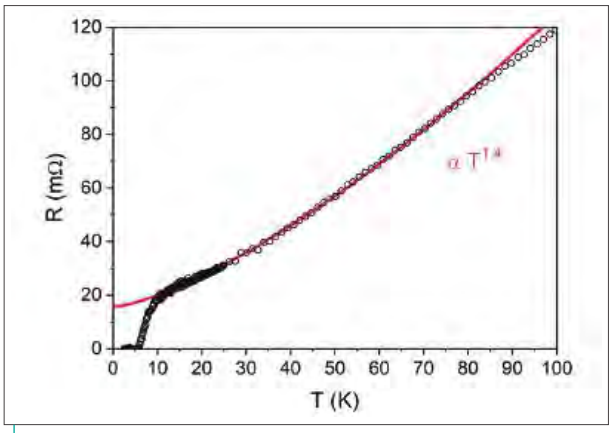

Fig. 2: *Resistivity measurement of $LaFeSiO_{1-\delta}$ evidencing the superconducting transition at T_c ~ 10 K.*

Collaboration

THEORY

Reference

M. F. Hansen, J.-B. Vaney, C. Lepoittevin, F. Bernardini, E. Gaudin, V. Nassif, M.-A. Méasson, A. Sulpice, H. Mayaffre, M.-H. Julien, S. Tencé, A. Cano & P. Toulemonde, "Superconductivity in the crystallogenide LaFeSiO1−δ with squeezed FeSi layers", npj *Quantum Mater.* 7, 86 (2022). https://doi.org/10.1038/s41535-022-00493-z.