Supplementary Information for "Robust magnetism against pressure in non-superconducting samples prepared from lutetium foil and H_2/N_2 gas mixture"

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1. Experimental details

1.1 High pressure heat capacity measurements

In the high-pressure heat capacity measurements, diamond anvils with 700 μm culets (flat area of the diamond anvil) and a non-magnetic rhenium gasket with 350-μm-diameter hole were adopted. In order to prevent the sample from short circuiting with the metallic gasket, an insulating layer composed of a thin mixture of c-BN powder and epoxy was applied. A constantan heater was placed on the one side of the sample to heat the sample and a chromel-AuFe (0.07%) thermocouple was fixed on the other side.

We also placed another thin insulating layer between the sample and the heater to avoid the short circuiting between the heater and the thermocouple. Subsequently, the sample was loaded into the sample hole filled with NaCl that can maintain the sample in a quasi-hydrostatic pressure environment and also isolate the heat flowing from the diamond anvil to ensure a quasi-adiabatic scenario [1, 2].

1.2 High pressure dc magnetic susceptibility measurements

The measurements of *dc* magnetization were carried out using a Quantum Design Magnetic Property Measurement System. A specially designed diamond anvil cell (DAC) was employed to generated high pressure. Diamond anvils with 500μm culets and a non-magnetic BeCu gasket with 250-μm-holes were adopted in the measurements. Silicone oil was utilized as the pressure transmitting medium and pressure was determined by ruby fluorescence [3].

2. High -pressure heat capacity measurements for the sample Lu-N-H-1800 °C

Heat capacity measurements were conducted on the sample Lu-N-H-1800 °C within a pressure range 0.2 - 3.2 GPa, and the corresponding results are illustrated in Fig. S1a-1d. No anomalous signal is observed in the high-temperature range 80 - 300 K, indicating the absence of a high-temperature superconductivity in this temperature regime. At ~0.2 GPa, a transition was observed at around 56 K and it persists up to 3.2 GPa at 57.8 K, indicating the existence of a magnetic phase, similar to that observed in the sample Lu-N-H-65 °C.

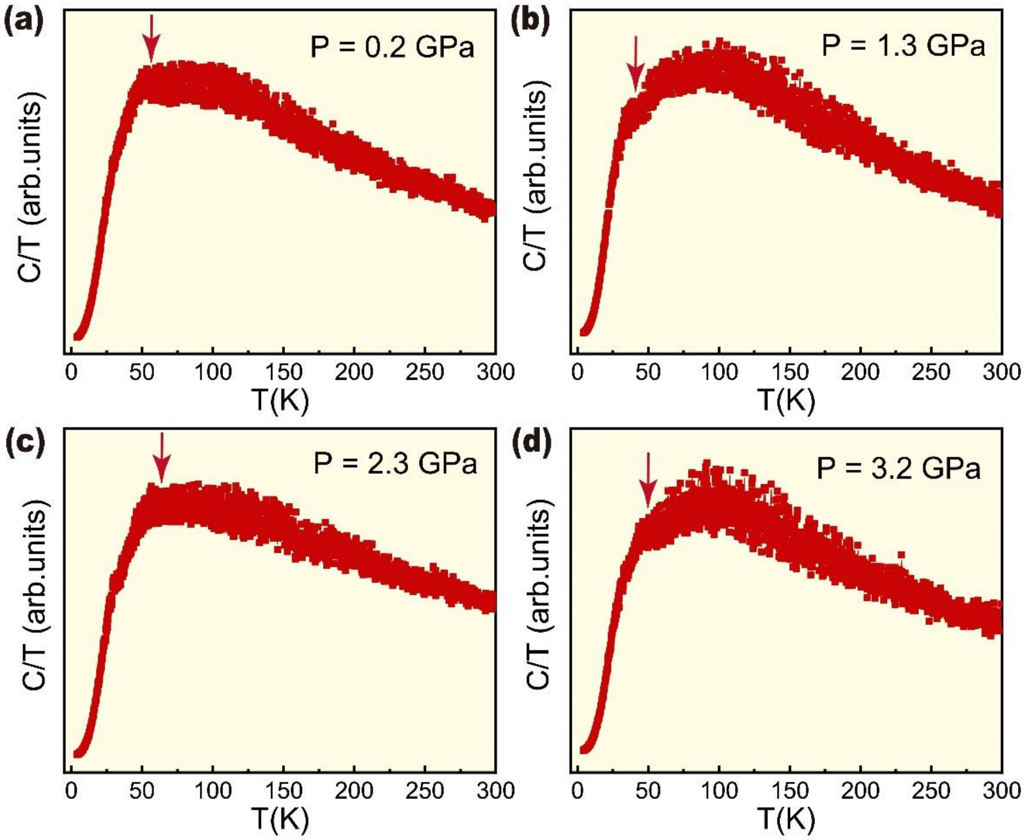

Fig. S1a-1d Temperature dependence of *C/T* for the sample Lu-N-H-1800° C measured in the pressure range 0.2-3.2 GPa and the temperature range 4 -300 K.

3. High pressure heat capacity measurements on $CaK(Fe_{0.96}Ni_{0.04})_4As_4$ superconductor

To justify the reliability of our heat capacity measurement setup, we used the same setup to check the high-pressure heat capacity on the $CaK(Fe_{0.96}Ni_{0.04})_4As_4$ superconductor with a magnetic transition at ~ 40 K and superconducting transition at ~21 K at ambient pressure [4-7]. Our previous resistance measurements showed that its magnetic and superconducting phases coexist at pressure below 2.5 GPa[4]. Here, the heat capacity measurement on the sample subjected to 0.5 GPa also showed the two transitions at approximately 37 K and 20 K (Fig. S2a), which well match the magnetic and superconducting transitions observed in the resistance measurements at a comparable pressure (0.8 GPa) for the same superconductor (Fig.S2b). Furthermore, no anomaly was observed at ~ 56 K in the plot of *C/T* versus temperature. All demonstrates that the experimental setup for the high-pressure heat capacity measurement is reliable, indicating that the data detected from the Lu-H-N samples are dependable.

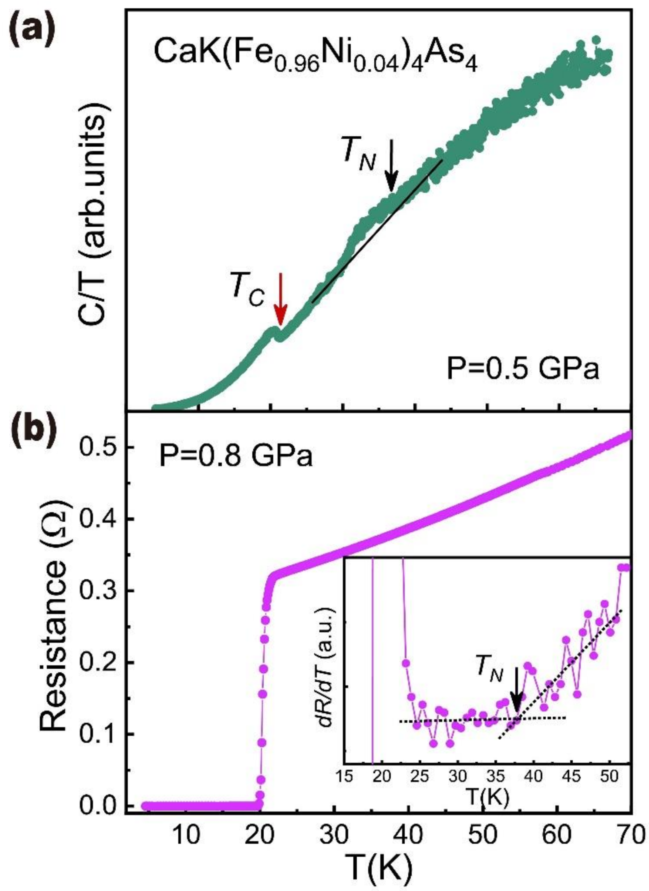

Fig. S2 (a) Heat capacity measurement performed on $CaK(Fe_{0.96}Ni_{0.04})_4As_4$ single crystal at 0.5 GPa. (b) Temperature dependence of resistance measured on the same sample subjected to 0.8 GPa. The inset displays the temperature derivative of electrical resistance (*dR/dT*). The intersection of the dash lines is the magnetic transition temperature.

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