Supporting Information

Nanostructure Engineering and Performance Enhancement in Fe_2O_3-Dispersed $Cu_{12}Sb_4S_{13}$ Thermoelectric Composites with Earth-Abundant Elements

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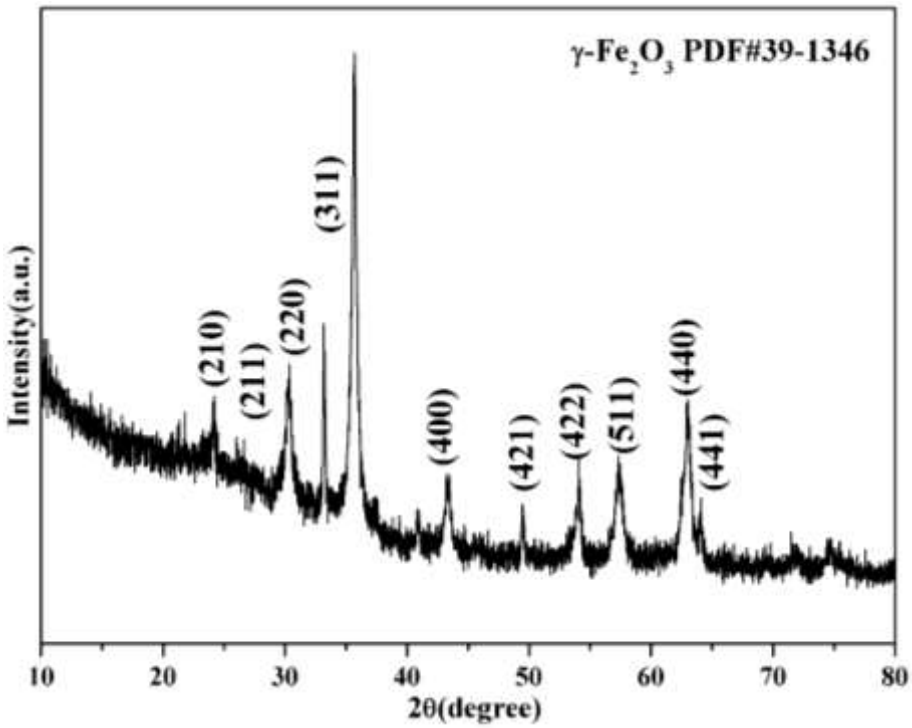

Figure S1 XRD pattern of the magnetic γ-Fe_2O_3 NPs.

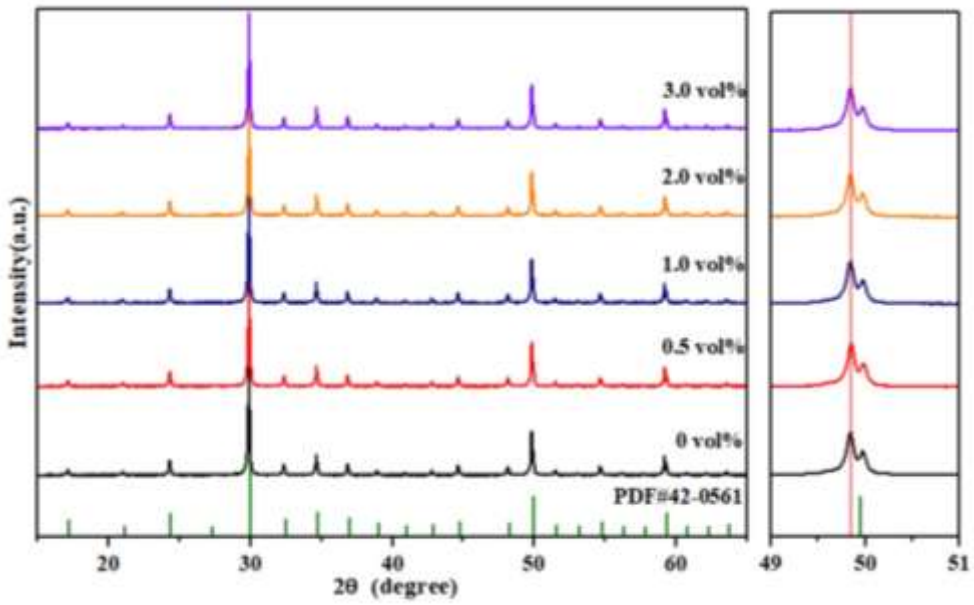

Figure S2 XRD pattern of the obtained CNAS-xFe$_2$O$_3$ (x = 0, 0.5, 1.0, 2.0, and 3.0%) samples, along with the enlarged peaks between 49 and 51°.

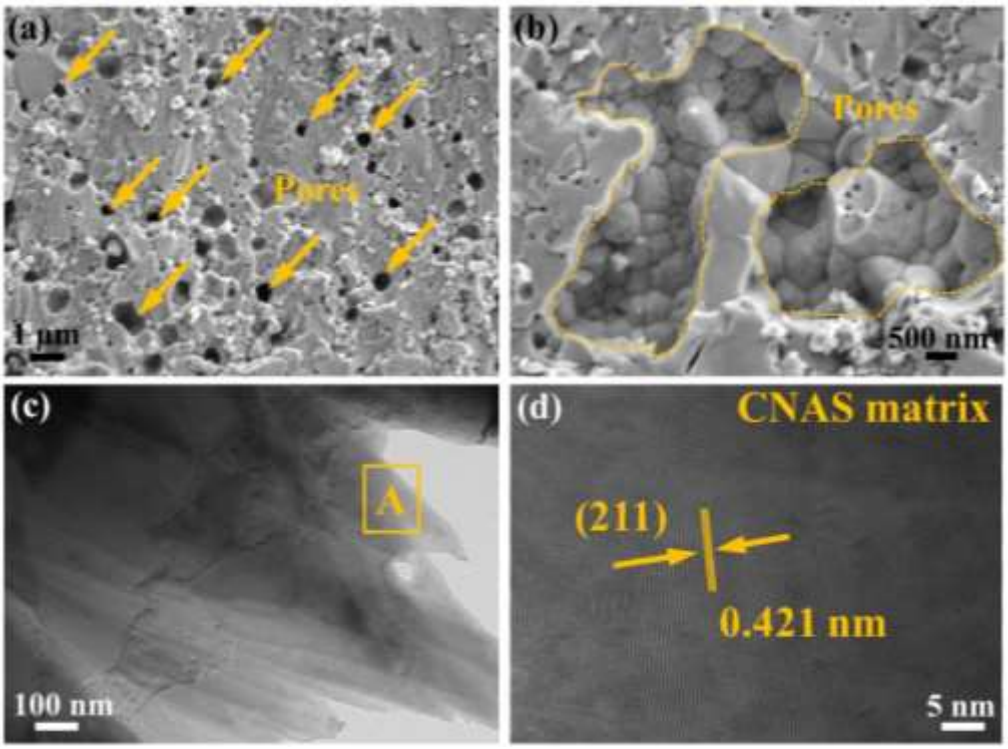

Figure S3 (a-b) FESEM image of the CNAS matrix on the fractured surface, low-magnification TEM image (c) and HRTEM image (d) of the CNAS matrix.

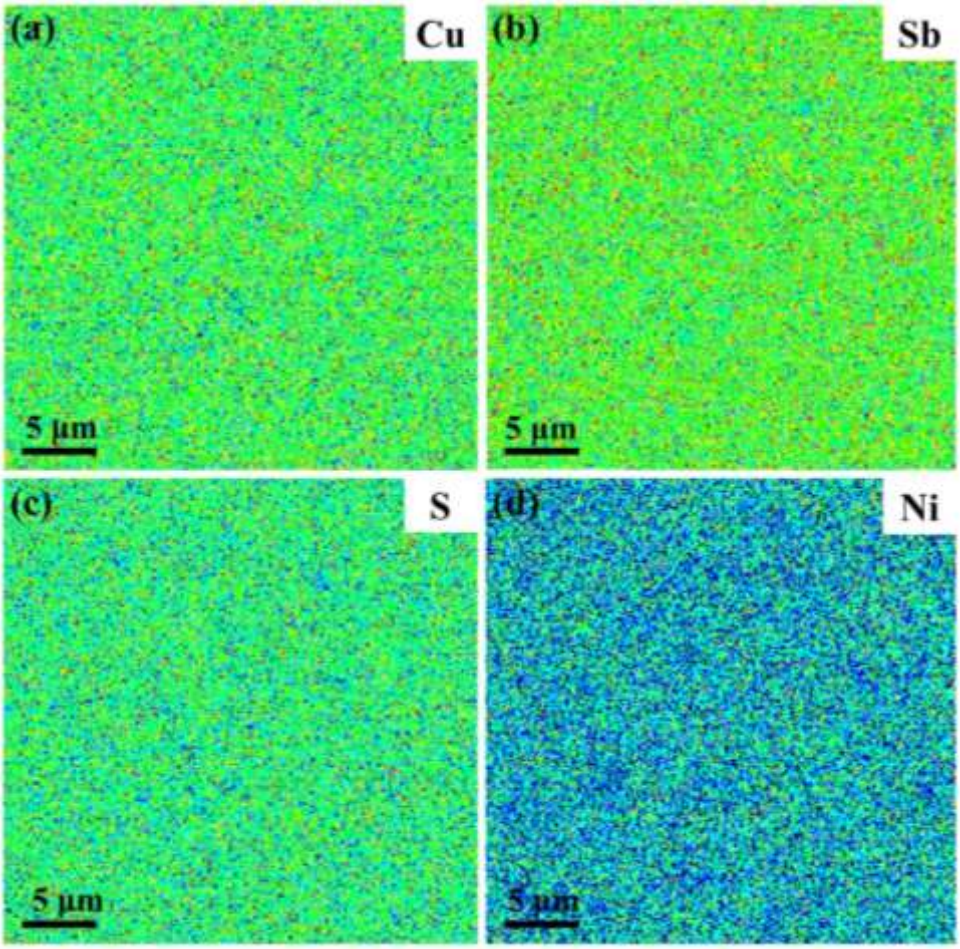

Figure S4 EPMA mapping of (a) Cu, (b) Sb, (c) S, and (d) Ni taken from the matrix.

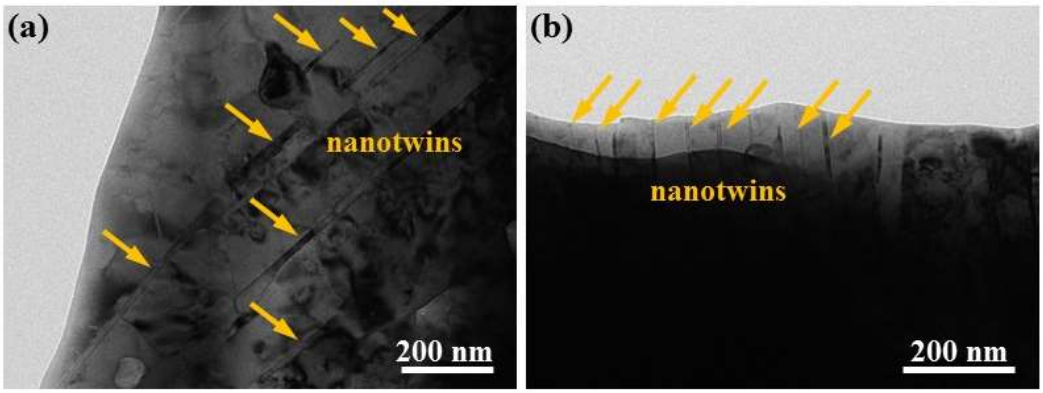

Figure S5 (a-b) Low-magnification TEM pattern of the nanotwins in different areas of the CNAS-1.0%Fe_2O_3 sample.

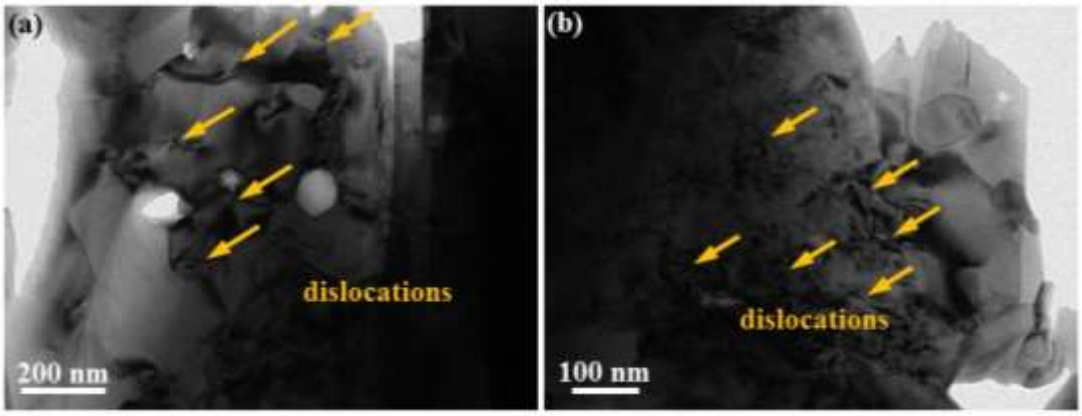

Figure S6 (a-b) Low-magnification TEM pattern of the dislocations in the CNAS-1.0%Fe_2O_3 sample;

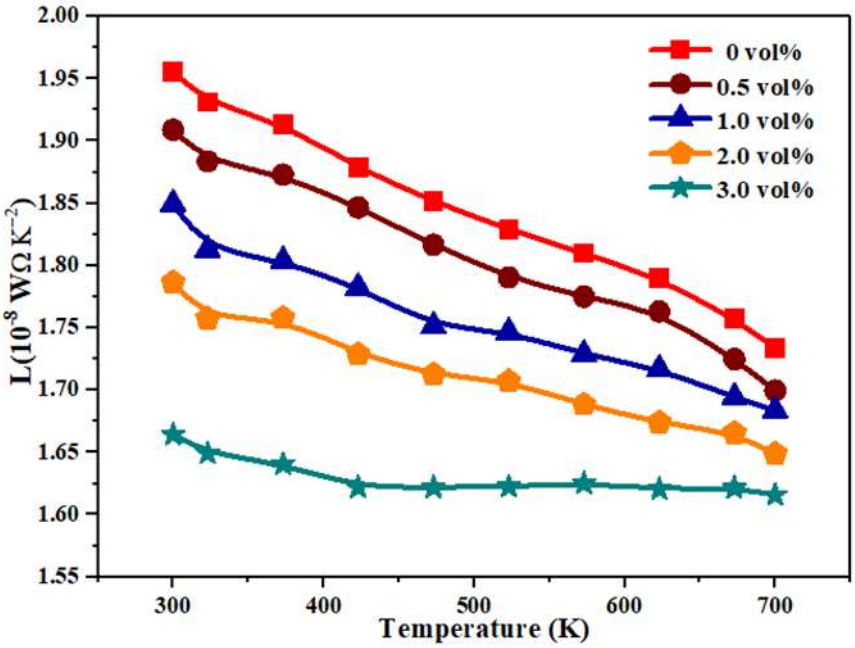

Figure S7 The calculated Lorenz number for the CNAS-xFe$_2$O$_3$ (x = 0, 0.5, 1.0, 2.0, and 3.0%) samples from 300 to 700 K.

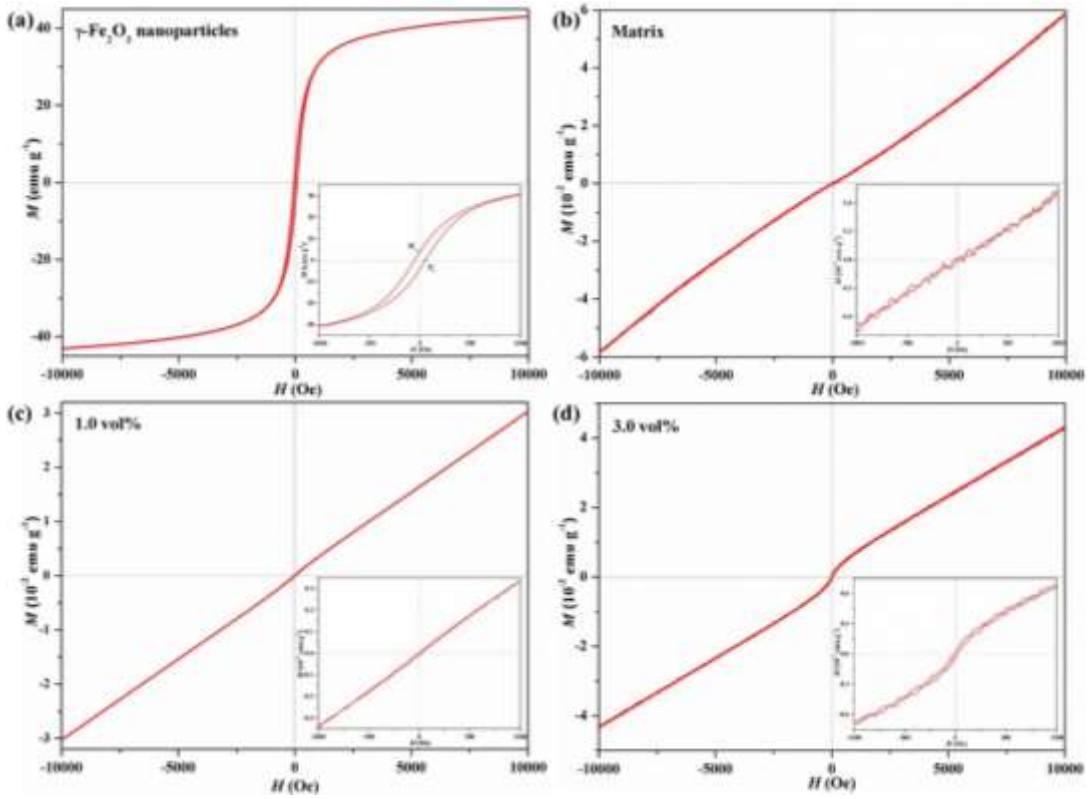

Figure S8 Magnetization versus magnetic field (*M*-*H*) plots for (a) the γ-Fe_2O_3 NPs, (b) CNAS matrix, (c) CNAS-1.0%Fe_2O_3, and (d) CNAS-3.0%Fe_2O_3 at room temperature.

The magnetic properties of the CNAS-*x*Fe_2O_3 were measured at room temperature and the results are shown in the Figure S8. The γ-Fe_2O_3 nanoparticles exhibit the strongest ferromagnetism as compared to the other three samples. The saturation magnetization (M_s), remnant magnetization (M_r), and coercivity (H_C) of γ-Fe_2O_3 nanoparticles are about 31 emu/g, 3.5 emu/g and 62.5 Oe. The matrix reveals paramagnetism. Additionally, the CNAS-1.0%Fe_2O_3 and CNAS-3.0%Fe_2O_3 also exhibit paramagnetism, which may be due to the low content of magnetic γ-Fe_2O_3 nanoparticles. There is no magnetic transition from ferromagnetism to paramagnetism in CNAS-*x*Fe_2O_3 in the range 300-700 K, because the Curie temperature (T_C) has been estimated as lying between 820 K and 986 K.[1]

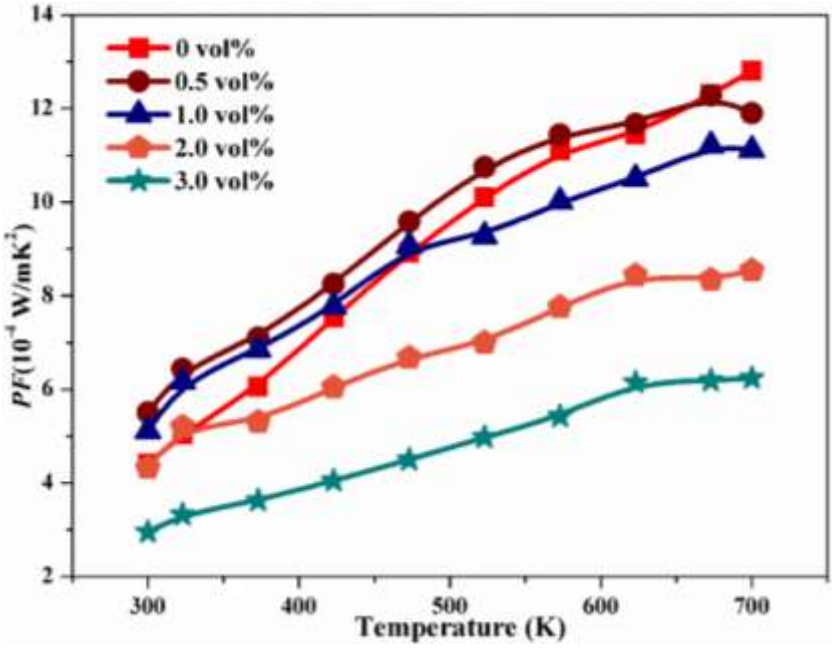

Figure S9 Temperature dependence of the power factor for all samples.

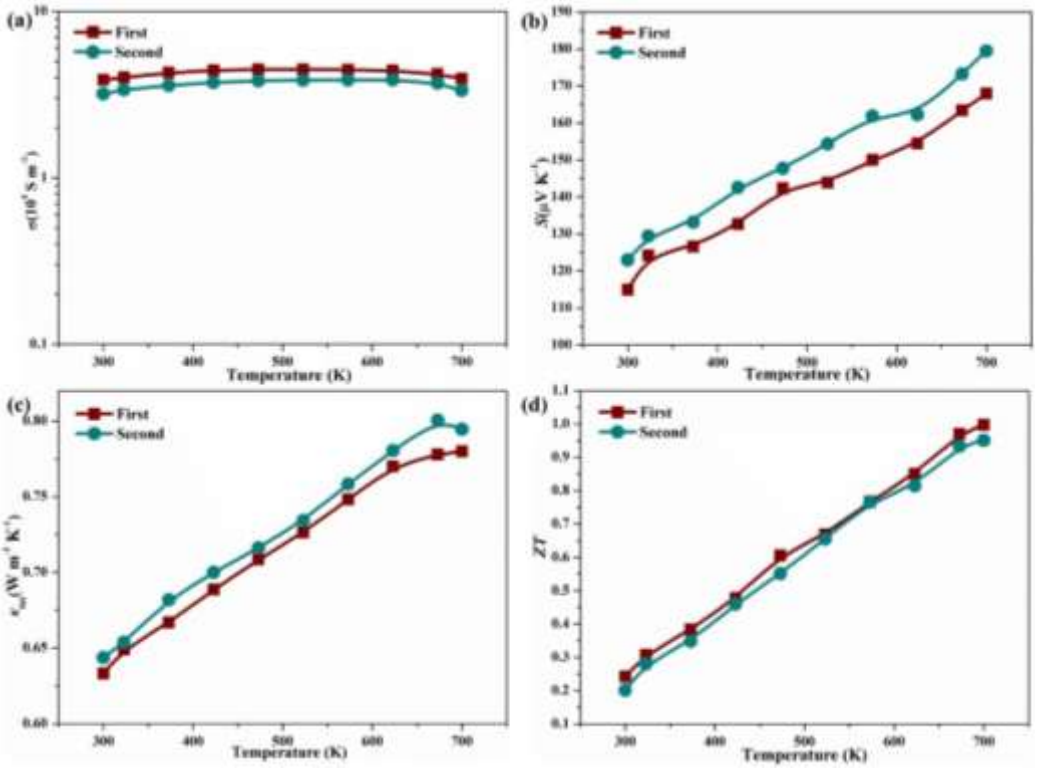

Figure S10 Repeat measurement of (a) electrical resistivity, (b) Seebeck coefficient, (c) thermal conductivity, and (d) calculated *ZT* value of CNAS-1.0%Fe_2O_3.

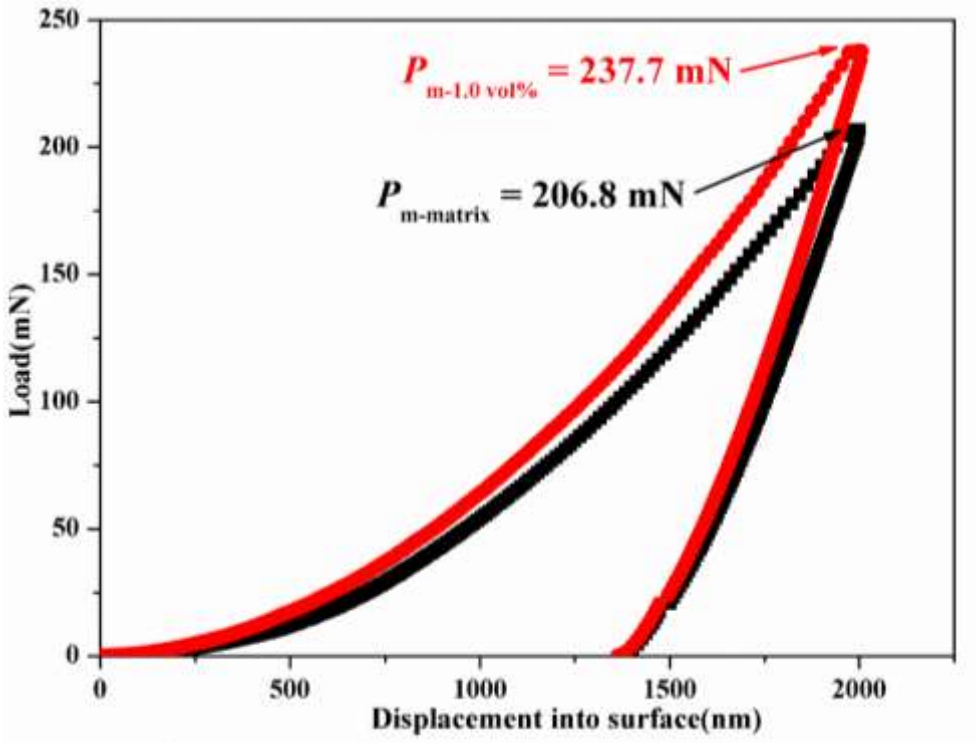

Figure S11 Curves of load as a function of displacement into the surface and the maximum load (P_m) is 206.8 and 237.7 mN for the matrix and CNAS-1.0%Fe_2O_3 composite, respectively.

Table S1 Density of different samples

Samples	Theoretic density	0%	0.5%	1.0%	2.0%	3.0%
Density (g/cm^3)	5.05	4.52	4.46	4.41	4.40	4.41

REFERENCES

(1) Cornell, R. M; Schwertmann, U. *The Iron Oxides: Structure, Properties, Reactions, Occurences and Uses*. Wiley-VCH, 2003; pp 128-130.