Synthesis and characterization of $LuFeO_3$ nanoparticles

In recent years, the ferroelectric materials have attracted much attention because of their promising applications in memory storage, sensors, microelectronic and spintronic devices [1]. $LuFeO_3$ is considered as typical second-generation multiferroic material after the star classical material $BiFeO_3$ [2].

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Methods of Investigation

- X-ray diffraction (XRD) method using Shimadzu LabX XRD-6000 diffractometer in $Cu_{K\alpha1}$-radiation (λ = 0.15406 nm) at room temperature
- Scanning electron microscopy (SEM) and Energy Dispersive Spectroscopy (EDS) method using FEI Magellan 400
- Transition electron microscopy (TEM) method using JEM-2200FS Transmission Electron Microscope
- Ferroelectric method using Precision Multiferroic II analyzer equipped by charge-based magnetoelectric response tester
- Magnetic method using Quantum Design SQUID MPMS-3

Results and Discussion

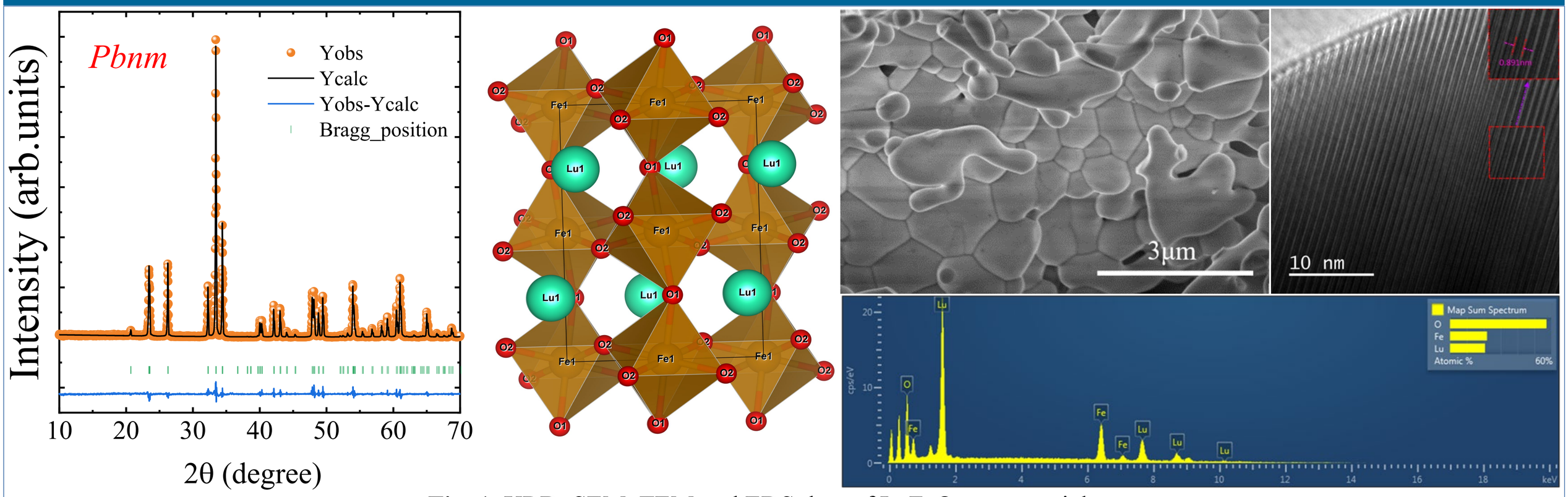

Fig. 1. XRD, SEM, TEM and EDS data of $LuFeO_3$ nanoparticles

According to XRD, the $LuFeO_3$ nanopowder can be indexed to the pure orthorhombic *Pbnm* perovskite structure with the lattice parameters of a = 5.21332(5) Å, b = 5.55150(5) Å, c = 7.56236 (6) Å and V = 218.868 Å^3 (Z = 4). According to SEM and TEM studies, the $LuFeO_3$ sample consists of fiber-like nanoparticles. Additionally, based on the EDS data, the chemical composition of the $LuFeO_3$ powder has been confirmed and approximately corresponds to stoichiometric ratio with Lu (19.63 at.%), Fe (21.36 at.%) and O (59.01 at.%).

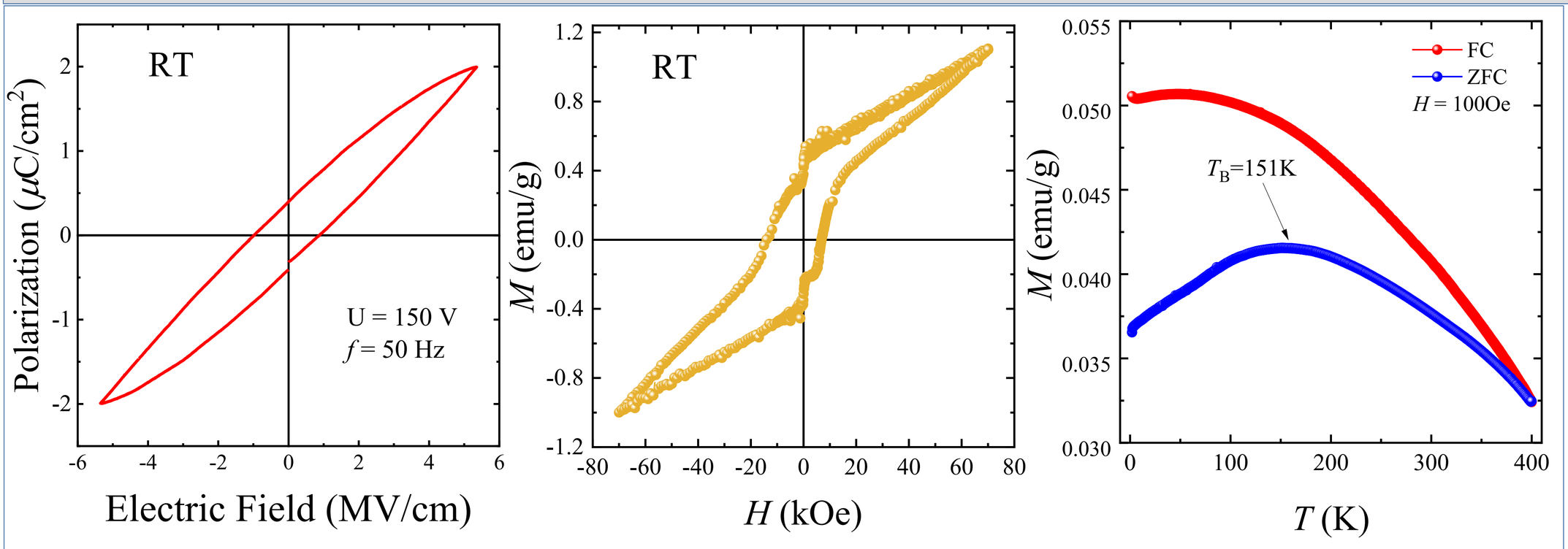

Fig. 2. Ferroelectric and magnetic properties of $LuFeO_3$ nanoparticles

The *P-E* loop shows ferroelectricity of $LuFeO_3$ at room temperature with the highest value of polarization $P_{max} \approx 2$ μC/cm^2 at U = 150 V and remnant polarization P_r = 0.4 μC/cm^2. The blocked temperature ~ 151 K at H = 100 Oe is obtained using ZFC - FC curves.

Conclusions

- The synthesized $LuFeO_3$ nanopowder exhibits pure orthorhombic perovskite structure with *Pbnm* space group.
- It has been established that $LuFeO_3$ nanoparticles have ferroelectric properties at room temperature, the values of which is in good agreement with other literature data for the same composition.
- $LuFeO_3$ nanopowder demonstrate weak ferromagnetism, the phase transition temperature of which is higher than 400 K.
- The obtained results show coexistence of ferroelectricity and ferromagnetism in the orthorhombic $LuFeO_3$ nanoparticles that opens up wide prospects for their practical application.

References

1. Chowdhury U., Goswami S., et al. Room temperature multiferroicity in orthorhombic $LuFeO_3$ // Appl. Phys. Lett. - 2014. - 105(5). - P. 321.
2. Wang Z., Xiao W., et al. Effects of mechanochemical activation on the structural and electrical properties of orthorhombic $LuFeO_3$ ceramics // J. Am. Ceram. Soc. - 2021. - 104(7). – P. 3019-3029.