One-Dimensional Multiferroic BaTiO$_3$-CoFe$_2$O$_4$ Core-Shell Nanostructures

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Abstract

A synthesis method has been developed for producing one-dimensional BaTiO$_3$-CoFe$_2$O$_4$ core-shell nanostuctures, which involves a combination of soft chemistry processes including hydrothermal-assisted ion-exchange synthesis, modified sol-gel process, and calcination.

Motivation

- Multiferroic materials: dual magnetic and ferroelectric properties with efficient coupling between them.
- Problems
  (a) Multiferroics combining ferromagnetism and ferroelectricity in the same phase is rare since ferromagnetism requires partially filled transition metal d orbitals and ferroelectricity is favored by empty transition metal orbitals.
  (b) Restricted to a limited number of materials, such as HoMnO$_3$. These usually have low ferromagnetic transition temperature and weak magnetoelectric coupling. Not suitable for practical applications.
- Alternative: Nanocomposites (multilayered thin films) having large surface area, high ferroelstc and magnetoelastic constants leading to large magnetoelastic coupling. Choice of materials with high ferromagnetic and ferroelectric transition temperatures makes room temperature operation feasible.
- One-dimensional multiferroic nanocomposites: shape and size-dependent physical properties are expected; much larger interface area and stronger magnetoelectric coupling; no clamping effect from substrate or template.
- Synthetic challenges: mismatch between the crystal structures and anisotropic structure of BaTiO$_3$ nanowires; different chemistries.

Experimental

Combining hydrothermal synthesis, modified sol-gel process, and subsequent calcination for preparing BaTiO$_3$ nanowires and coating of the BaTiO$_3$ nanowires with CoFe$_2$O$_4$ to form one-dimensional BaTiO$_3$-CoFe$_2$O$_4$ core-shell nanostructures.

Conclusion

We have successfully obtained one-dimensional BaTiO$_3$-CoFe$_2$O$_4$ core-shell nanostructures using a combination of soft chemistry routes. The magnetoelectric properties of these nanostructures will be investigated.

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