

Preparation of FeNi powders/ butyl rubber nanocomposite film and its force sensitive characteristic



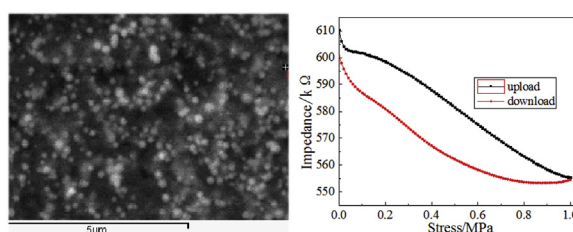
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HIGHLIGHTS

- FeNi powders/Butyl rubber nanocomposite film, powders mass content 65wt%, was harvested successfully.
- Films show superior force sensitivity when stress is 0.20–0.90 MPa.
- Films can be used as a contact stress sensor via the calibration of the impedance–stress standard equivalent function.

GRAPHICAL ABSTRACT



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ABSTRACT

Firstly, the spherical Fe50Ni50 powders, particle size about 100 nm, were prepared by liquid phase reduction method, and then were mixed with butyl rubber (IIR) dispersed in liquid. Fe50Ni50 powders/IIR nanocomposite films, powder mass fraction was 65 wt%, were harvested through being mixed and milled lastly. The force sensitive properties of the films were studied under the condition of that the loading/unloading speed of the stress was 0.10 mm/min controlled by the LYYL-500N high-grade microcomputer controlling compression-testing machine, and the test frequency of impedance (Z) was 1 kHz tested with the TH2816B LCR digital electric bridge. Results show that Fe50Ni50 powders can be dispersed uniformly as nanometer scale in this nanocomposite by liquid phase mixing method. And the Fe50Ni50 powders/IIR nanocomposite film, thickness 185 μm , has excellent force–sensitive properties when the stress is between 0.20 MPa and 0.90 MPa. The impedance ~ stress curve appears approximately linear decline, and stress sensitivity $|k|$ value is stable in 40–60, stability S value is about 1–2 k Ω , and the film enters into a steadily sensitive stage responding to stress.

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1. Introduction

The flexible force sensor is a kind of flexible electronic device, for perception of surface force distribution, with a broad application prospect in the fields of robotics, biomechanics, medicine measurements and so on, and gradually attracts the attention of people [1–4].

Up to now, the force sensitive characteristics of films consisted of FeCuNbSiB and FeSiB magnetic powders as the sensitive elements and the silicone rubber (SiR) as the matrix are detailedly studied [5–7]. Results show that the force sensitive characteristic of the composite material films is more excellent with smaller powder particle size and stronger magnetism of magnetic powders. However, the particle size of FeCuNbSiB and FeSiB prepared by mechanical crushing method is around 30 μm , which leads that the thickness of the composite film is more than 300 μm [5–9]. Therefore, FeNi nano-powders/SiR composite film, thickness less than 200 μm , is developed with excellent force–sensitive

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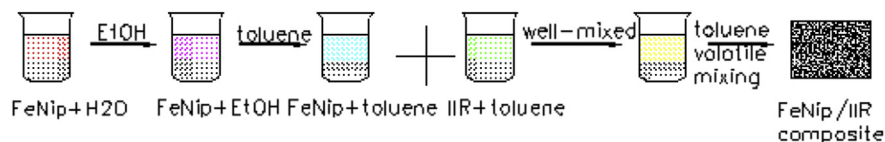


Fig. 1. Flow chart of Fe50Ni50/IIR composite material preparation (FeNip: Fe50Ni50 powders).

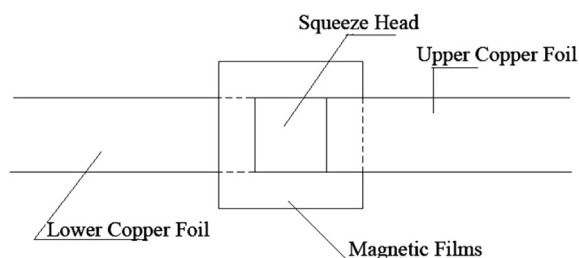


Fig. 2. Test schematic diagram under the condition of compressive stress.

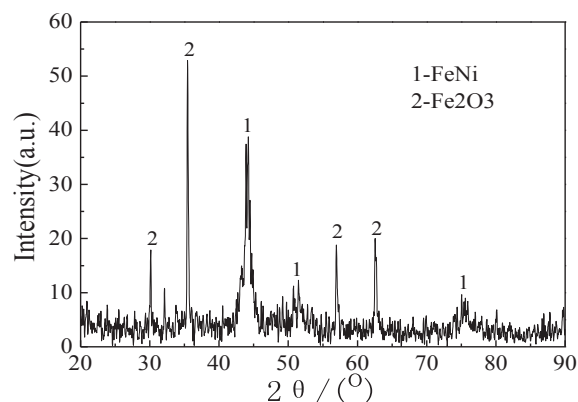


Fig. 3. XRD spectrum of Fe50Ni50 powders.

properties. But the new issues are that low strength and poor adhesive property of SiR matrix material lead that the thin film encapsulation is difficult, restricting the application of the SiR matrix force sensitive films [10–17].

On the basis of the researches of FeNi powders/SiR nanocomposite film, the preparation process of FeNi nano powders was further improved, and butyl rubber (IIR) with high strength and good adhesive properties was adopted as the matrix material, and the problem of nano-scale dispersion in IIR as solid state was solved. The nanocomposite with thicknesses of 185 μm and 290 μm respectively and high powder mass fraction 65wt%, was successfully prepared and the force sensitive characteristics of the films were studied.

2. Experiment

2.1. Preparation of FeNi powders/IIR nanocomposite film

NiSO₄ (Jinchuan Group Co., Ltd, CP) and FeSO₄ (Xilong Chemical Co., Ltd, AR) were prepared into water solution by Ni/Fe = 1/1 (atom %) ratio, then NaOH (Damao chemical reagent factory in Tianjin, AR) was added to adjust the pH, about 14, and the solution was heated to 80–85 °C, at last appropriate amount of hydrazine hydrate (Damao chemical reagent factory in Tianjin, AR) was added. The solution reacted vigorously for about 30 min, and the reaction process was associated with colorless and irritating gas volatile out, at last black powders were generated. A magnetic separation method was used to separate the powders from a large amount of water and a paste of black powders with a small amount of water

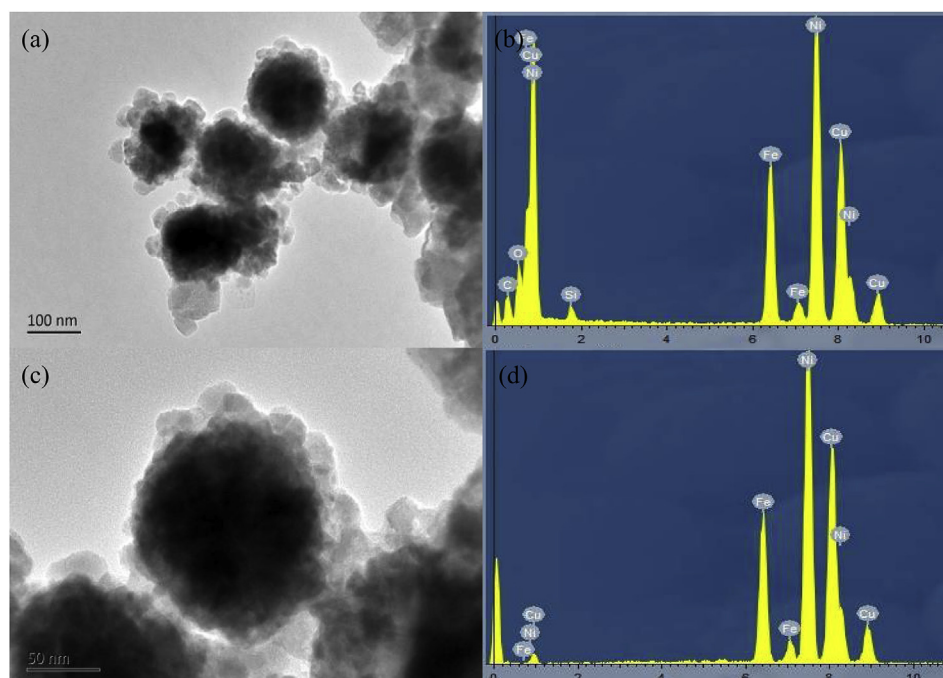


Fig. 4. TEM photos of Fe50Ni50 nanoparticles.

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