MAGNETIC POLYMERS

M. F. Thorpe, Becton Center, Yale University, New Haven, CT, 06520

Recent experiments on poly(metal phosphinites) suggest that amorphous magnetic polymers are interesting new materials. In this talk we discuss some experiments that might yield useful information about the magnetic and conformational properties of magnetic polymers. Static measurements, like specific heat and susceptibility, can give information about the magnetic ordering. However, neutron measurements of the wave vector dependent susceptibility \( X(k) \) and the scattering law \( S(k, \omega) \) can give more detailed information about the magnetic properties and more importantly, about the conformations of the polymer chains (in particular, the chain length and end-to-end distance).

We set up some simple models in order to investigate the kind of behavior to be expected. We show that the form of \( X(k) \) is modified when the correlation length associated with the magnetic ordering becomes comparable with the chain length. The neutron scattering law \( S(k, \omega) \) measures essentially the spin wave density of states at low temperatures although there is some \( K \) dependence which reflects the amount of conformational disorder. A full account of this work is given in reference 2.

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HIGHLY MAGNETOSTRICTIVE RARE EARTH ALLOYS

A. E. Clark
U. S. Naval Surface Weapons Center
White Oak, Silver Spring, MD 20910

Within the last few years, huge magnetostricions have been achieved at room temperature in the Laves phase RFex alloys (\( R = \) rare earth). Strains \( > 2 \times 10^{-6} \), over ten times those of previously known polycrystals, have been observed in TbFe2 and SmFe2. The rare earth-Fe2 compounds, while exhibiting the largest known room temperature magnetostrictions, possess a wide range of cubic magnetic anisotropies, ranging from the largest positive value of \( 2 \times 10^{-6} \) erg/cm3 (for DyFe2) to the largest negative value of \(-7.6 \times 10^{-6} \) erg/cm3 (for TbFe2). Room temperature values of magnetization, magnetic anisotropy, and magnetostriction are listed in the table below:

<table>
<thead>
<tr>
<th>( M ) (emu/cm3)</th>
<th>( K ) (x10^6 ergs/cm3)</th>
<th>( \lambda_p ) (x10^{-6})</th>
<th>( \lambda_{111} ) (x10^{-6})</th>
</tr>
</thead>
<tbody>
<tr>
<td>SmFe2</td>
<td>4400</td>
<td>-2300</td>
<td>-2100</td>
</tr>
<tr>
<td>TbFe2</td>
<td>800</td>
<td>-7.6</td>
<td>2600</td>
</tr>
<tr>
<td>DyFe2</td>
<td>800</td>
<td>2.1</td>
<td>640</td>
</tr>
<tr>
<td>HoFe2</td>
<td>300</td>
<td>-0.3</td>
<td>300</td>
</tr>
</tbody>
</table>

Here \( \lambda_p \) (\( \approx -\lambda_{111} \)) denotes the fractional change in length of a polycrystal as a magnetic field is rotated from perpendicular to parallel to the measurement direction.

An unprecedented magnetostrictive anisotropy, \( \lambda_{111} > \lambda_{100} \), characterizes these compounds. For DyFe2, \( \lambda_{100} = 0.24 \times 10^{-6} \). The huge rare earth magnetoelastic interaction is effectively shorted out in the cubic Laves phase RFex compounds when \( M \parallel [100] \). This \( \lambda_{111} > \lambda_{100} \) anisotropy dictates a magnetostrictive strain that depends almost exclusively on domain wall motion rather than on magnetization rotation. An atomic model for the anisotropic magnetostriction, based upon the symmetry at the rare earth site, has been proposed. The ternary alloy, \( Tb_xDy_{1-x}Fe_2 \), possesses a high magnetostrictive/ strain ratio. Magneto-mechanical coupling measurements on this alloy reveal coupling factors, \( k^'s = 0.6 \), making these materials attractive for magnetostrictive transducer applications.

Prototype transducers have been designed at both government and industrial laboratories. In addition, the elastic moduli of this alloy are found to be strongly field dependent. The fractional change in Young's modulus, \( AE/E = 150\% \) at 10 kHz. The sound velocity increase upon magnetization, associated with this modulus change, is 5%. Many applications of rare earth magnetostrictive materials are currently emerging. These include acoustic delay lines, variable frequency resonators, active millisecond valves, and micropositioning devices.