Influence of Bi and Sb cations on the electric and magnetic properties of Mg doped copper ferrites

Thesis
Submitted for the degree of
Ph.D.
In Solid State Physics

By
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To
Physics Department
Faculty of Science
Cairo University

2010

تأثير كاتيونات البزموث و الأنتيمون على الخواص الكهربية و المغناطيسية لفريت النحاس المطعم بالماغنسيوم

رسالة مقدمه

لقسم الفيزياء – كلية العلوم – جامعة القاهرة

لنيل درجة الدكتوراة

فيزيقا الجوامد

على أحمد محمد عزب

٢٠١٠

Abstract

The investigated samples were prepared by two techniques the standard and wet methods (sol-gel, citrate and co precipitation). Three groups were prepared by the standard ceramic technique with the formula.

1- The first group has the formula $Cu_{1-x} Mg_x Fe_2 O_4$ where $0 \leq x \leq 0.6$

2- The second group has the formula $Cu_{0.7} Mg_{0.3} Sb_y Fe_{2-y} O_4$ where $0.05 \leq y \leq 0.25$

3- The third group has the formula $Cu_{0.7} Mg_{0.3} Bi_z Fe_{2-z} O_4$ where $0.05 \leq z \leq 0.25$

The sample with x=0.3 ($Cu_{0.7} Mg_{0.3} Fe_2 O_4$) was prepared by the wet methods under different conditions.

X-ray diffraction patterns show that, the first group showed cubic spinel structure with small intensities of secondary phase at $0 \leq x \leq 0.2$ after which no secondary phases were exist, in the second group, secondary phases appears at y=0.15 , 0.25. While in the third group single phase cubic spinel structure was obtained. The sample with x=0.3 was prepared by co precipitation method at different PH values (9-13.5) and it is sintered at different temperatures (200-950 ^oC) for 3 hrs. Also the sample with x=0.3 was prepared by citrate and sol-gel methods. The lattice parameter and X-ray density for the above mentioned samples were calculated and reported.

The IR spectra for the prepared samples, were carried out in the rang of 200-700 cm^{-1} in order to confirm the formation of the samples in the proper form. Four bands indicating the spinel structure were obtained, two of them ν_1, ν_2 are of high frequency and the other two ν_3, ν_4 are of low frequency.

The transmission electron microscope (TEM) was performed to explore the particle shape and size, micrographs reveals different shapes, homogeneities and particle size. Sol-Gel method gave the smallest particle size (8.7 nm), while the ceramic method gave the largest particle size (127.8 nm).

The electrical conductivity was measured at different temperatures as a function of frequency (10 kHz–5MHz). The AC conductivity increases with increasing temperature giving three regions; the first one is stable region (flat region) while the other two are with different slopes indicating the different conduction

mechanisms. The general trend was a decrease in the conductivity with increasing the concentration of the cations Mg^{2+}, Sb^{3+} and Bi^{3+}.

The real part ($\varepsilon^{/}$) and the imaginary part ($\varepsilon^{//}$) of dielectric constant were studied as a function of temperature and frequency (100 kHz – 5MHz). The variation of the dielectric constants depends mainly on the valence exchange between the different metal ions either of one element or two different elements. The parameters $\varepsilon^{\backslash}$ and $\varepsilon^{\backslash\backslash}$ showed a decrease with increasing of Mg^{2+}, Sb^{3+} and Bi^{3+} concentrations and an increase with increasing temperature.

Seebeck coefficient measurements were carried out with temperature to investigate the type of charge carriers. Generally, we have found that the small polarons as well as the electrons contribute to the conduction process. The use of the small polaron hopping interprets the positive values obtained for Seebeck coefficient of most samples.

The molar magnetic susceptibility (χ_M) for the samples was studied at different temperatures as a function of the magnetic field intensities. The magnetic parameters such as Curie temperature (T_C) and the effective magnetic moment (μ_{eff}) were calculated from the experimental data and reported. The data showed that, all parameters were decreased with increasing Mg^{2+}, Sb^{3+} and Bi^{3+} concentrations. This is due to the replacement of the paramagnetic and ferromagnetic cations with diamagnetic ions, on octahedral site which decreases the A-B exchange interaction.

The magnetic parameters obtained from hystersis for the sample prepared by different methods (ceramic, sol- gel, coprecipitation and citrate) show that, they changed depending on the preparation methods. High coercivity was obtained for the nanorods shaped sample (citrate method) 125.6 Oe. Highest saturation and remanant magnetization (9.87 emu/g) was achieved for the sample prepared by the standard ceramic technique. Finally one can control the magnetic characterizations by using the suitable method of preparation.

جامعـــة القـــــاهرة

الإدارة العامة للدراسات العليا
والبحوث

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استمارة معلومات الرسائل التي تمت مناقشتها

١ـ الدرجة العلمية: دكتوراه

٢ـ بيانات الرسالة:

الكلية: العلوم القسم: الفيزياء

عنوان الرسالة باللغة العربية:

تأثير كاتيونات البزموث و الأنتيمون على الخواص الكهربية و المغناطيسية لفريت النحاس المطعم بالماغنسيوم

عنوان الرسالة باللغة الأجنبية:

Influence of Bi and Sb cations on the electric and magnetic properties of Mg doped copper ferrites

التخصص الدقيق: فيزياء جوامد

تاريخ المناقشة:

٣ـ بيانات الطالب:

الاسم: على أحمد محمد عزب الجنسية: مصري النوع: ذكر

العنوان: ميت أبوعربى – مركز الزقازيق – محافظة الشرقيه رقم التليفون: ٠٥٥٢٠٦٣٥٦٩

جهة العمل: المركز القومى للبحوث رقم الفاكس: البريد الالكتروني: aliazab@hotmail.com

٤ـ المشرفون على الرسالة:

الاســـــم	القسم	الكلية	الجامعة
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٢ـ د علاء الدين عبد اللطيف	فيزياء	العلوم	القاهرة
٣ـ أ. د حسن حسن عفيفى	فيزيقا الجوامد	المركز القومى للبحوث	
٤ـ أ.د إيناس أحمد كمال الزواوى	فيزيقا الجوامد	المركز القومى للبحوث	

==========

٥- مستخلص الرسالة:

٥-١ باللغة العربية:

الكلمات الدالة: فيريتات – نانو – نحاس – ماغنسيوم- بزموث – أنتيمون- نفاذيه مغناطيسيه

تم تحضير ثلاث مجموعات من المركبات بطريقة السيراميك ذات الصيغه

١- المجموعة الأولى لها الصيغة $Cu_{1-x} Mg_x Fe_2 O_4$ حيث $0 \leq x \leq 0.6$

٢- المجموعة الثانية لها الصيغة $Cu_{0.7} Mg_{0.3} Sb_y Fe_{2-y} O_4$ حيث $0.05 \leq y \leq 0.25$

٣- المجموعة الثالثة لها الصيغة $Cu_{0.7} Mg_{0.3} Bi_z Fe_{2-z} O_4$ حيث $0.05 \leq z \leq 0.25$

العينة التى لها الصيغة ($Cu_{0.7} Mg_{0.3} Fe_2 O_4$) تم تحضيرها بطرق الكيمائية و تحت ظروف تحضير مختلفة للحصول على عينات نانو متريه.

تم استخدام حيود الأشعة السينية و تحت الحمراء فى المدى $200cm^{-1}$ الى $700\ cm^{-1}$ للتأكد من تكون العينات فى الصورة Spinel . تم أخذ صور للعينات بالميكرسكوب الألكترونى النافذ لمعرفة حجم و شكل البلورات وقد وجد أن طريقة sol-gel أعطت أصغر حجم بلورى (٨.٧ نانومتر) و طريقة السيراميك القياسية أعطت أكبر حجم بلورى (١٢٧.٨ نانومتر).

تم قياس التوصلية الكهربية المترددة والجزء الحقيقى والجزء التخيلى لثابت العزل الكهربى كدالة فى درجة الحرارة و قيم مختلفة للتردد (١٠ كيلو هرتز- ٥ ميجا هرتز).

تم قياس القابلية المغناطيسية و حساب الثوابت المغناطيسية من منحنى عروة التخلف المغناطيسى للعينات المحضرة بطرق مختلفة و قد وجد من النتائج أن قيم الثوابت المغناطيسية تعتمد على طرق التحضير و قد أعطت طريقة Citrate شكل قضبان بلورية نانومترية أعلى قيمة للمجال القسرى (١٢٥.٦ أورستد).

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٢-٥ باللغة الأجنبية: (Abstract)

Key Words: Ferrite, nanoferrite, copper, magnesium, bismuth, antimony, magnetic susceptlity, thermo eclectic power, conduction mechanism.

Three groups of investigated samples were prepared by the standard ceramic technique with the formula.

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٦- أهم النتائج التي تم التوصل إليها:

٦-١ من الخواص الكهربيه و جد ان العينات تعطى مقاومة كهربيه عاليه و من الخواص المغناطيسيه وجد القيم المنخفظة H_C تجعل من المادة ملائمة لعمل قلب المحولات الكهربية ذات القدرات العاليه.

٦-٢ من الخواص الكهربيه و العزليه تجعل من الماده مناسبة L-C فى الدوائر الكهربيه

٦-٣ الماده لها قدرة امتصاص للموجات الكهرومغناطيسيه تجعلها ملائمة فى عمل تغطيه لكابلات البيانات لمنع التداخل بين الاشارات.

٦-٤ المادة لها خواص للتطبيق كمستشعر للرطوبة.

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٧- ما هي الجهات التي يمكن أن تستفيد من هذا البحث:
الصناعات الكهربيه و الالكترونيه (المحولات الكهربيه – الدوائر الالكترونيه)
– الاتصالات (كمبيوتر- و كابلات نقل البيانات)
٨- هل توجد علاقة بإحدى هذه الجهات: لا

٩- هل توافق على التعاون مع جهات مستفيدة من خلال الجامعة: نعم

(أ) لتطبيق البحث.
(ب) لاستكمال البحث.

١٠- هل تم نشر بحوث مستخرجة من الرسالة في مجلات أو مؤتمرات علمية: لا

١١- هل تم سبق التقدم لتسجيل براءات اختراع: لا

١٢- هل توافق على إعطاء البيانات المذكورة في هذه الاستمارة لجهات أخرى: نعم

توقيع الطالب/
على أحمد محمد عزب

توقيع المشرفين:

وكيل الكلية للدراسات العليا والبحوث:

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Cairo University
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Summery:

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Approval Sheet

Influence of Bi and Sb cations on the electric and magnetic properties of Mg doped copper ferrites

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Thesis

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2008

[illegible]

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لقسم الفيزياء-كلية العلوم -جامعة القاهرة

لنيل درجة الدكتوراه

على أحمد محمد عزب

٢٠٠٨