ISSN : 0974 - 7435 Volume 10 Issue 19

2014

BioTechnology

An Indian Journal

FULL PAPER

BTAIJ, 10(19), 2014 [11200-11205]

Study on thermal conduction for low-dimension magnetic materials

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ABSTRACT

The thermal conduction research process of low-dimensional magnetic material is a complicated process. In this process, the higher requirement on growing condition of monocrystal is proposed. For growing process of, the thermal conduction conditions produce the important influence on monocrystal forming; in the process of growing, the temperature produces important function on success acquisition of monocrystal. In this paper, the conditions are searched through crystal growing, structural surface characteristics and physical property survey so that the growing conditions of monocrystal can be established. In combination with structural characteristics of monocrystal, the verification method is described effectively. Secondly, through physical property survey, DC magnetisability and magnetization curve of crystal are obtained effectively to judge the crystallization of crystal. Afterwards, the comprehensive discussion n and study are conducted for monocrystal growing, structural surface characteristics and physical property research; finally, the thermal conduction discipline for low-dimensional magnetic materials is obtained. This kind of study thought sufficiently embodies the study contents and study purpose so as to reach the requirement that the study process of this paper is provided with stronger theoretical and practical requirement and ensure that the study thought of this paper is further close as well as ensure that the scientificity of study method and study process can also be reflected. Thus, it is hoped that the study and discussion for this paper may provide the powerful support for effective implementation of further deepening the study work in future.

KEYWORDS

Low-dimensional magnetic material; Monocrystal Growing; Hermal conduction; Exploration and study.

INTRODUCTION

In the study process for thermal conduction of low-dimensional magnetic materials, the corresponding study and discussion are conducted mainly pertaining to such aspects as crystal growth, structural characteristics and physical property survey, physical property survey, crystal growth, structural surface characteristics and physical property survey in this paper so as to sufficiently explore the main environment and external conditions of monocrystal growth process as well as effectively verify the quality and characteristic of monocrystal in combination with corresponding verification means so as to describe the inherent discipline and characteristics of thermal conduction for low-dimensional magnetic materials. Through this study process, the study route of this paper is closer, meanwhile, the scientificity and rationality on study results are guaranteed sufficiently.

CRYSTAL GROWTH, STRUCTURAL CHARACTERISTIC AND PHYSICAL PROPERTY SURVEY

Monocrystal growth

$Ba_3Mn_20_8$crystal is manufactured by NEIYOUGUANGZI through traditional high-temperature solid phase reaction, the shown state is crystal powder form. However, in 2008, E.C.Samulon etc. effectively dissolved the sodium hydroxide and treated it as the effective cosolvent for use. While, in this experimental process, the main method refers to slower cooling process, thus, the massive monocrystal is obtained. In the growing process of $Ba_3Mn_20_8$crystal, the effective appraisal is performed for manufacturing method adopted by E.C.Samulon etc., and the cooling speed and specific efficiency of cooling so as to obtain the massive monocrystal[1].

In the growing process of $Ba_3Mn_20_8$monocrystal, the primitive and traditional method is mainly adopted for implementation to mainly perform the corresponding slow-speed cooling via the cosolvent so as to enable it to be of self-seeding nucleation. While, this growing process may be divided into two steps mainly:

First step: the high-temperature solid-phase reaction method is adopted to prepare the polycrystal powder with high purity, the main process; the main process mainly enables that the barium carbonate that the purity reaches 99.99% reacts with manganese dioxide that the purity reaches 99.99% under 500℃ high temperature, and then, scientifically weigh Ba_3Mn20_8 via drying process as well as effectively mix and grind it, after that, place it into Al_20_3into griddle for effective burning and ensure that the combustion temperature is at1000℃,the combustion time is 100hs. In this process, the calcination and grinding process for repeated and many times is required in this process until that the crystal powder presents the dark green[2]. After the powder is diffracted by X ray, it is determined that the poly crystal is divided into Ba_3Mn20_8single-phase form, the specific conditions are as shown in Figure 1.

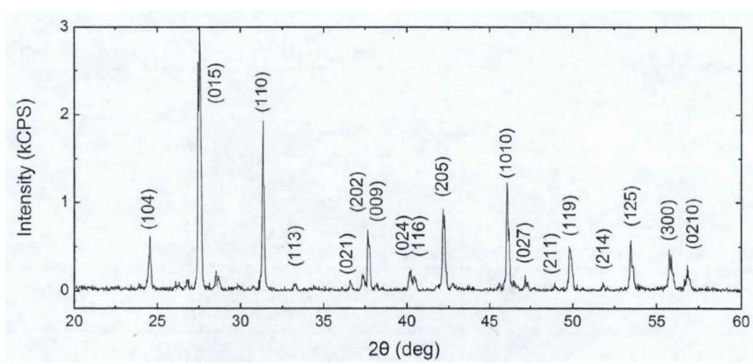

Figure 1 : X-ray diffraction of ba3mn208 multicrystal power

Second step: growing process of monocrystal, in Ba_3Mn20_8crystal, since the valence presented by manganese ion is positive5valence, thus, a requirement is raised for cosolvent method in the growing process of crystal, the anhydrous sodium hydroxide with strong oxidation and lower melting point must be served as unique cosolvent. In the initial growing process, E.C.Samulon's experiences are appraised toremain the mixed proportion of polycrystal powder and sodium hydroxide being 1:19 for effectiveplacement. Al_20_3griddle is still selected for container. Through effective application for barrel-type heat resistance mode, the heat resistance furnaceis heated continuously, within 24hs after heating, the temperature reaches 700℃ and this temperature is remained for 5hs. After that, the slow cooling process is conducted to ensure that the temperature falls down to 300℃. This cooling process requires 200h duration, finally, the temperature drops down to room temperature. After ending the cooling process, claw out the aid agent of sodium hydroxide along the wall of griddle and then dissolve the sodium hydroxide by employing the deionized water, however, the tendency that the monocrystal grows here is not found. However, the possible reason that the aid agent crawls out lies in overtemperature in the process of baking, therefore, this phenomenon may be solved though cooling means[3].

However, Considering that the melting point of anhydrous sodium hydroxide is 318.4℃, the temperature of monocrystal growth shall be adjusted as 500 ℃; meanwhile, considering that the saturated concentration may produce the reduction after the dissolving temperature falls, thus, the Moore proportion of sodium hydroxide and Ba_3Mn20_8 is adjusted as 30:1, after the temperature reaches 500 ℃ and retains for 5 hours, after that, the temperature is reduced down to 300 ℃; on the final stage, the temperature is reduced down to room temperature. While the temperature falls down to room temperature, extract the sodium hydroxide and find that 1 mmhexagonal monocrystal grows up.

However, it is hoped that more monocrystal can be gotten, the means and methods are adopted to continuously prolong the growth time. In the growth process of monocrystal, since the temperature is reduced slowly, the temperature reduction speed should be reduced continuously, however, the size of monocrystal gotten in this process may largen, the color becomes black, the growth parameters in this monocrystal may be shown through TABLE 1, while the color may be shown via Figure 2.

TABLE 1 : Comparison table for K condition of $Ba_3Mn_2O_8$monocrystal

	$Ba_3Mn_2O_8$	Moltening Temperature	Temperature reduction speed	Dimension of Monocrystal
First time	1:19	700℃	2℃/h	None
Second time	1:30	500℃	2℃/h	1mm
Third Time	1:30	500℃	1℃/h	4mm

Surface characteristic of crystal structure

The symmetry of this monocrystal and judgment means shall be judged effectively via X-ray. However, in the judgment process of large block of crystal, the microcosmic technical means must be adopted to perform the corresponding process, in this process. One of most important technical means is to perform the effective diffraction via X-ray[4]. However, in the process that the X-ray diffraction of this monocrystal is performed, X-ray from PANalytical Company is mainly adopted to perform the effective diffraction process, in this process, CuKa incident ray is acquired via graphite monochromator, the wave length is $\lambda = 1.5046\mathring{A}$, the measuring angle is selected to be between10-60 degree, in this process, the most single surface of hexagonal flake monocrystal is served as the diffraction surface, the specific conditions are as shown in Figure 2.

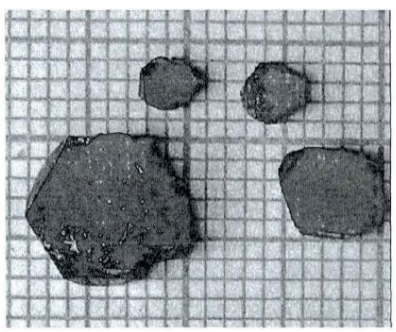

Figure 2 : $Ba_3Mn_2O_3$ monocrytal photograph

In the determination process of crystal axis direction for monocrytal, the whole-journey scanning is adopted for means generally, the scanning results may be observed from Figure 3(b). While it is observed from the scanning results of flake sample, the largest surface is $(00l)$ surface, in this process, (009) diffraction peak value is selected to perform the rocking measurement process, the measurement results can be embodied from Figure 3(a), while it may be observed from the results that the width of half-height is only of 0.18°, what's more, in this measurement results, the phenomenon that the diffraction peak produces the crack is not found. It may be observed from this detection result that this crystal sample is provided with better crystallization orientation, and the accompanied twining phenomenon isn't produced.

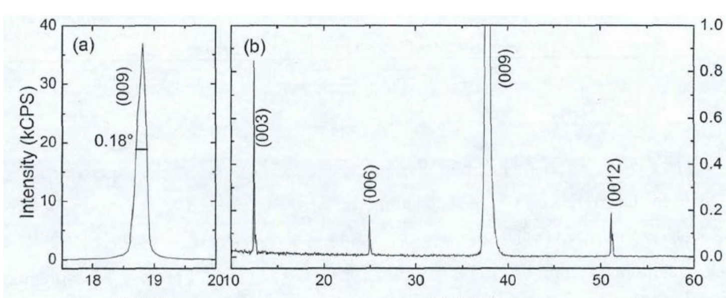

Figure 3 : (a) Rocking Curve of Diffraction Peak for Monocrystal Sample (009);(b) Whole-journey Scanning Result of (00/) Surface

However, the quality of growing-up monocrystal $Ba_3Mn20_8$and crystal axis must be effectively determined, in this process, the monocrystal obtained in combination with the backscattering method shall be detected effectively. In this process, Laue photographing means is adopted to obtain the diffraction pattern for both ab sides, the specific conditions are as shown in Figure 4. It may be observed from Figure 4 that the symmetry phenomenon between the pattern of ab sides and central axis, while, in this pattern, the corresponding fracture phenomenon is not found so as to obtain higher quality of monocrytal itself[5].

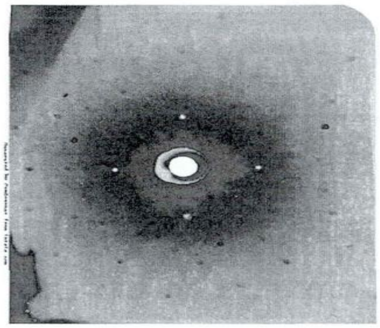

Figure 4 : Diffraction pattern of laue photographing on ab sides of $Ba_3Mn_2O_8$monocrystal

PHYSICAL PROPERTY MEASUREMENT

In the process of physical property measurement for crystal, the magnetic measuring system from American Quantum Design Company is selected mainly to perform the relevant test, in this process, the further measuring process of DC magnetization rate and magnetization curve is performed mainly for measuring length of Ba_3Mn20_8monocrytal along parallel and vertical c direction. However, the obtaining way of specific heat data in the null field is realized through comprehensive physical measuring system from American Quantum Design Company by adopting the heat relaxation method in the process of measuring. In this process, the temperature of terrain 0.4k is measured through the plugins of refrigerator, meanwhile, prior to implementation for this measuring test, the back bottom shall be marked effectively so that the specific experimental data can be obtained scientifically. However, in the measuring process of thermal conductivity, the main methods may be developed through two steps, first step: perform the galvanic coupler measurement for constantan and nickel-chromium on ^4He pulsatron refrigerator as well as effectively calculate the temperature difference so as to obtain the thermal conductivity data between4kand 300 under null field. However, under the condition of lower temperature (0.3-8k), the calculation process of thermal conductivity is measured through functioning two thermometers and one heater on the ^3He refrigerator and 14T super coducting magnet. However, prior to performing the measuring process of external magnetic field, the resistancevalue of resistance thermometer in different magnetic fields shall be set scientifically so that the accuracy in the measuring process can be improved obviously, the resistance value is determined as[4,16,17].

MEASUREMENTON MONOCRYSTAL GROWTH, STRUCTURAL CHARACTERISTIC AND PHYSICAL PROPERTY MEASUREMENT

In the growth process of monocrystal Ca3Co206and Ca3CoMnO6monocrystal, the references shall be appraised mainly and effectively so as to obtain corresponding growth methods and ways. Through fully utilizing this K2CO3 cosolvent, the growth environment and conditions are adjusted in pertinence. First step: effectively fuse this monophase Ca3Co409powder by adopting the stoichiometric proportion method, and through 900℃ high temperature and 100h calcining process so as to sufficiently obtain Ca3Co409. In addition, in the calcining process, the grinding process for repeated and multiple times is performed so that two kinds of powder can be mixed sufficiently to ensure that the reaction process is sufficient and thorough. However, in the growth process of $Ca_3Co_20_6$, K_2CO_3 shall be served as the corresponding cosolvent, while such two kinds of $Ca_3Co_40_9$ and K_2CO_3powder are effectively mixed in accordance with 1:7 mass proportion ratio, the mixture is placed into aluminum oxide griddle and heated up to 950℃ within retained hours, while this temperature is cooled after remaining 150 hours, the speed should remain 0.35 ℃ per hour. And then, after dropping down to 880℃, perform the natural cooling so that the temperature can reduce down to temperature[6]. After this process ends, sufficiently wash K_2CO_3 by employing the deionized water so as to obtain the hexagonal monocrystal. Figure 5 shows this monocrystal picture. However, in this growing process, this kind of existingphenomenon may be found. When the temperature is at 880℃, the high-quality monocrystal cannot be obtained, however, the melting point of cosolvent $K_2CO_3$is at 890℃, the temperature in the growth process of monocrystal is lifted up to 950℃ and the growing time is prolonged continuously so as to obtain larger monocrystal.

However, the growth process of Ca_3CoMn0_6 is strongly similar to the growth process of$Ca_3Co_2O_6$, the main difference is that Mn replaces $Ca_3C0_2Mn_20_9$ powder for growing raw materials, in this process, the sufficient mixing is performed via $CaCO_3$, C0O and MnO_2 according to the chemical mass ratio, after that, the calcination and grinding process for many times should also be performed until the mono-phase crystal produces, the monocrystal growing in this process also presents the acicular hexagon as well.

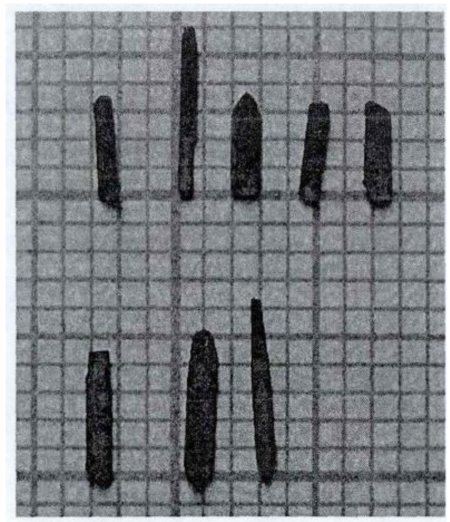

Figure 5 : $Ca_3Co_20_6$ monocrystal photograph

X-ray diffraction can finely determine the crystal structure, the crystallizing orientation and can also be served as the means to detect other impurities in the sample. In order to ensure that the grown crystal is $Ca_3C0_2O_6$ and CasCoMnOe and there isn't miscellaneous in the crystal, we shall utilize the deionized water to carefully wash $Ca_3Co_20_6$和Ca_3CoMn0_6monocrystal, after being ground as powder respectively, perform the measurement of X-ray diffraction. X-ray diffraction of sample in the room temperature is performed on the horizontal-type high power X-ray diffract meter TTR-III from Natural Science Company, the wavelength A of monochrome CuKa incident ray obtained through graphite monochromator is 1.5418A, the measuring angle20 is between15degree -75degree. The results shown in Figure 6 (a)and (b) are the measuring results of X-ray diffraction that $Ca_3Co_2O_6$ and Ca_3CoMnO_6monocrystal is grinded as powder. In $Ca_3C0_20_6$ and Ca_3CoMnO_6 figure, the diffraction peak of other phases is not observed, therefore, it may be shown that the miscellaneous phase doesn't exist in our sample. The location of diffraction peak in XRD figure of $Ca_3CoMnO_6$is nearly consistent with the diffraction peak of $Ca_3Co_20_6$, the substitution of Co ion by Mn ion doesn't lead to the obvious change of crystal structure[7].

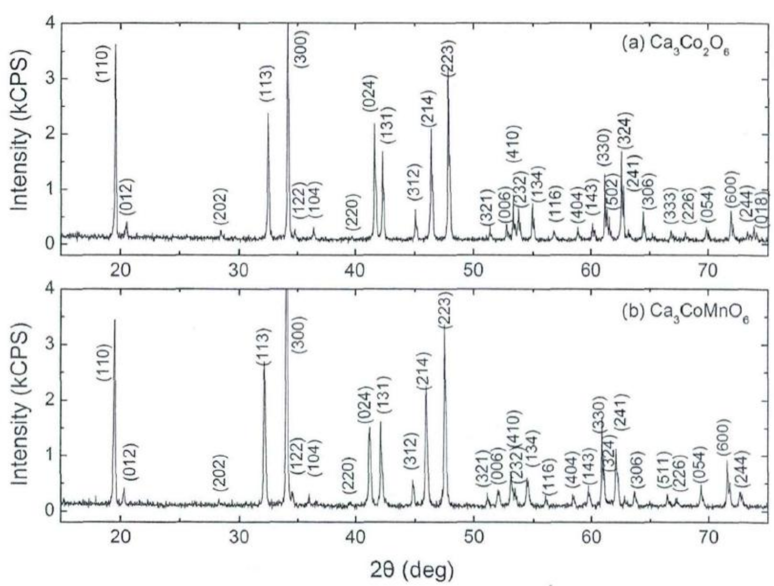

Figure 6 : X-ray diffraction figure that$_{Ca3C0206}$ and Ca_3CoMnO_6monocrytal is grinded as the powder

X-ray diffraction of monocrystal can determine the crystallographic axis direction of crystal, and the crystallization quality of crystal can be determined through half-height width of rocking curve for diffraction peak. We have known from previous results that the length direction of acicular $Ca_3C0_20_6$ and Ca_3CoMn0_6monocrystal is c axle direction. In order to specially determine which is the crystal face of acicular sample, we shall perform the whole-journey scanning for X-ray diffraction of monocrystal on the side. The results are as shown in Figure 7(b), the side of hexagonal prism monocrystal is (110) surface, the diffraction peak for other surfaces doesn’t occur in the figure. Figure 7(a) shows the rocking curve of (110) diffraction peak, only the half-height width that the size is O.ir shows that our monocrystal sample is provided with sound crystallization orientation, the phenomena influencing the quality of crystal don’t occur in the crystal.

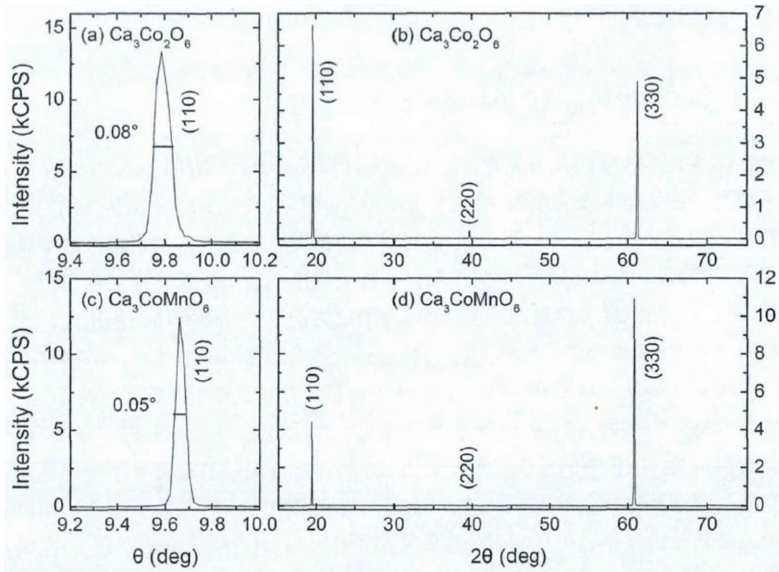

Figure 7 : (a) Rocking curve of (110) diffraction peak for Ca3C02O6Monocrystal X-ray diffraction; (b) Whole-journeyscanning for X-ray diffraction on the side of CasCoaOs monocrytal hexagon prism

CONCLUSION

Above is the corresponding study and exploration process pertaining to heat conduction of low-dimensional magnetic materials, therein, an effective study is performedin combination with actual conditions and environmental factors and effective verification is performed pertaining to results of monocrystal growth so as to enable that the characteristic of heat conduction can be shown apparently and guarantee that the study results are provided with stronger theoretical property and scientificity.

ACKNOWLEDGEMENT

Key Project on Scientific and Technical Research in Henan Provincial Education Department, Project No. 14A140020;

Planning Project on Base and Advanced Technology in Xuchang，Project No. 1404007

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