Advances in Computer Science Research, volume 78

3rd International Workshop on Materials Engineering and Computer Sciences (IWMECS 2018)

Energy Conversion Analysis of Ti_2SnC Synthesized by Ti Sn and C Mixed Powders

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Keywords: Ti_2SnC; Mechanical alloying; Energy conversion

Abstract: Ti_2SnC ceramic powder was synthesized by mechanical alloying process. The energy conversion of Ti_2SnC process was analyzed. The results show that the kinetic model of Ti_2SnC is established by mechanical alloying. When the mechanical alloying Ti_2SnC parameter is determined, the relationship between the rotational speed and the critical time value is $tc = 8.7 \times 1011\omega^{-3.4}$. To meet the critical energy of the reaction, it will be synthesized Ti_2SnC.

1. Introduction

Ti_2SnC is a new type of conductive material, it has good conductivity, thermal conductivity and excellent machine ability; at the same time with thermal shock resistance, high elastic modulus and good oxidation resistance [1-3].Ti_2SnC because of its own good self-lubricating, commonly used in heat exchanger materials and solid lubricants. In addition, Ti_2SnC also often as a reinforcement phase, the preparation of copper and aluminum and other composite materials. At present, more and more methods of synthetic Ti_2SnC at home and abroad have no pressure sintering, discharge plasma sintering and self-propagating reaction synthesis.

Mechanical alloying is a kind of preparation process which uses high energy ball to make the powder diffuse and solid state in the non-equilibrium state to form new materials. It has the advantages of simple operation and alloying at room temperature [4-5]. Mechanical alloying is a stochastic process involving factors that are interdependent or independent. In this paper, the synthesis of Ti_2SnC conductive ceramics by high energy ball mill was carried out. The kinetic model of Ti_2SnC synthesized by mechanical alloying and the mechanical simulation of mechanical alloying were analyzed synthetically. The energy conversion in mechanical alloying process was analyzed.

2. Experimental Material

In the experiment, Ti powder and Sn Powder C powder were used as raw materials, and Ti_2SnC was synthesized by mechanical alloying. The powders were analyzed by D/Max2500PC X-ray diffractometer (Cu target, Kα) and JSM-5600LV scanning electron microscopy.

3. Results and Analysis

3.1 Particle Morphology and Phase Analysis of Mechanical Alloying.

Fig.1 shows the morphology and phase composition of the powder obtained by mechanical alloying under the condition of ball mill speed of 500 r / min, ball diameter Φ12 mm, ball ratio of 10 1 and ball milling for 10 h. Figure 1 (a) shows that the morphology of the powder is mainly granular particles, while the existence of a small amount of layered structure, the smaller particle size has reached about 500 nm.Fig.1 (b) shows that the Ti_2SnC diffraction peak is the main peak in the XRD pattern, and there are TiN and Ti and Ti.

3.2 Dynamic Simulation of High Energy Ball Mill.

The ball mill is mechanically alloyed by the swing of the ball mill. The kinematic simulation shows that the trajectories of the ball mill are shown in Fig. 2, in which the three "8" -shaped curves above the base surface are the actual trajectories of the ball mill and the projection of the other three

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directions on the base surface is "8"Shape.It is found that the trajectory of the ball mill in the past planetary ball mill is a one-dimensional or two-dimensional simple vibration or swing, and the kinematic trajectory of the high-energy ball mill can be a three-dimensional complex movement. This movement strengthens the tank in the air of the multi-dimensional, increased the powder - grinding ball - tank wall contact with the three opportunities, greatly improving the ball mill grinding energy and efficiency.

The grinding ball, the powder and the tank wall inside the ball mill produce energy through mechanical collision and then realize the mechanical alloying process. The grinding ball directly affects the energy transfer process and the efficiency of the powder. Is the key to analyze the energy transfer in the process of mechanical alloying. Therefore, the use of simulation technology to simulate the movement of the ball and analysis. It was observed that the ball was dispersed in the ball mill when the ball was in the space "8", which provided a guarantee for the full collision of the ball, the powder and the tank wall, while ensuring the shortest mechanical alloying reaction Time and maximum efficiency. Through the multi-frequency, complex and random motion of the grinding ball, the powder can get more reaction energy. When the powder reaches the critical point of the self-propagating reaction, the powder will produce mechanical alloying reaction to generate new material.

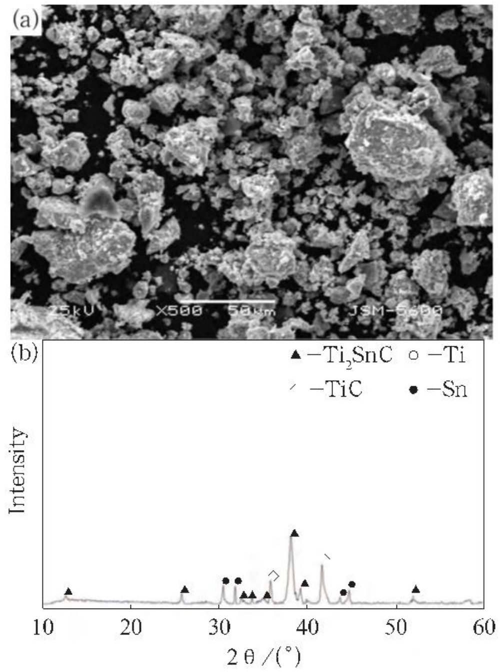

Fig.1 SEM image and XRD pattern of Ti2SnC

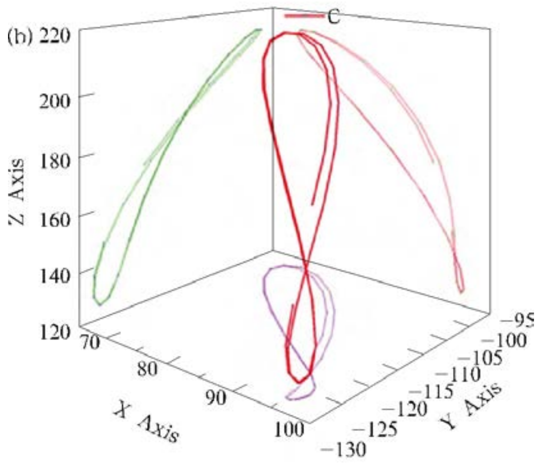

Fig.2 Trajectory of milling jar prepared by mechanical alloying

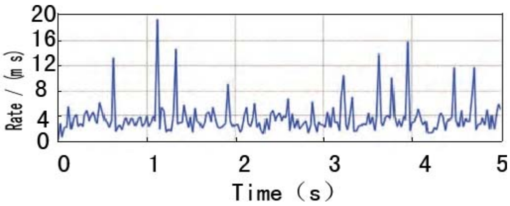

Fig.3 Relationship curve of grinding rate and time

3.3 Mechanical Alloying Energy Transfer Analysis.

Fig.4 shows the time-rate curve of the single grinding ball in the simulation process. It is found that the rate and formation time of the single grinding ball are not obvious. The data in Fig. 3 is derived and finally the energy and time curves of a single ball are obtained. As shown in Fig. 4, the energy produced by the grinding ball increases with the lapse of time.

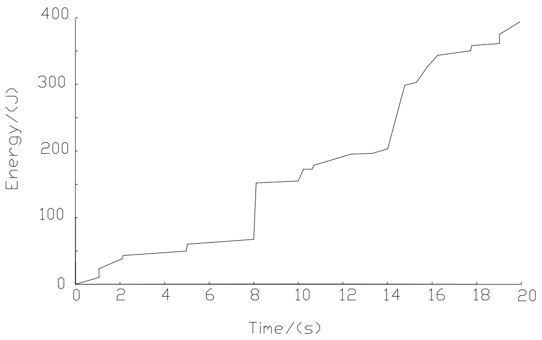

Fig.4 Relationship between milling energy and time

3.4 Mechanical Alloying Synthesis Ti2SnC Powder Kinetic Model.

In the process of mechanical alloying, the interaction between the ball mill media and the powder system is actually very complex, but for simplification of the problem, this interaction can be simplified as:

(1) The impact of ball milling media on the impact of local powder system.

(2) The ball mill between the sliding friction on the local powder system shear.

The mechanical energy of these two kinds of ball milling media is transformed into the strain energy, defect energy and chemical energy of the powder system, so as to realize the energy transfer in the MA process. When the ball mill medium is less (Ie filling rate n_v = N_b / Ntot smaller, N_b for the MA process the number of balls used, N_{tot} for the ball filled with the number of ball mill), the collision is MA process energy transfer. When the ball mill medium, need to consider the interaction of sliding friction [6]. According to the study of Magini and Iasonna [7], by introducing a parameter Φb, the energy transfer at the time of friction is equivalent to the impact of the impact action. The parameter Φb is related to nv, and the larger the nv is, the smaller Φb is. The filling rate used in this test is n_v = 1/3, according to Magin's test results can only consider the impact of the ball between the ball on the contribution of energy accumulation. Assuming that the energy delivered to the powder is ΔE, the mass of the ball is mb, and kc is constant. According to the Magini model, the energy ΔE absorbed by a single collision powder is: $\Delta E = Kcmb\omega^2$, ie ΔE ω^2 (1).The frequency f of the ball collision can be approximated as f ω^{n-2}.When the milling time is t, the energy E absorbed by the powder can be approximated as: $E = \Delta Eft = K\omega^n t$ (2).Assuming that E is equal to the critical value C, the self-propagating reaction occurs in the ball mill. The corresponding milling time can be defined as the critical time tc under the ball milling condition. The critical time can be expressed as follows: $t_c = (C / K)\omega^{-n}$ (3)..If the coefficient C / K is C_K, it becomes $tc = (C_K)\ \omega^{-n}$ (4).Suppose that CK and -n are constant when the self-propagating reaction occurs just under different ball milling conditions. According to the experimental data to determine CK and-n can be used formula (4) can be estimated at different speed milling time of the critical time tc. Using the calculation function of Origin and the experimental data of Table 1 to determine $Ck = 8.7 \times 10^{11}$, n = -3.4. The formula for determining the critical time tc is: $tc = 8.7 \times 10^{11}\omega^{-3.4}$ (5)

Fig. 5 is a graph showing the relationship between the critical time and the rotational speed of Ti_2SnC synthesized by mechanical alloying.It is found that when the ball mill speed is 500 r / min, the synthesis time is about 10 h, and the critical time of synthesis decreases with the increase of ball mill speed.

The mechanical model of Ti_2SnC synthesized by mechanical alloying and the mechanical simulation of mechanical alloying were analyzed synthetically. Among them, the Ti, Sn and C mixed powder is 25g, the speed is 500~575 r/min, the critical time of the reaction synthesis Ti_2SnC and the total energy absorbed by the powder are shown in Table 2. The energy produced by the ball is dissipated in the heat transfer to the surrounding environment. As the ball milling process progresses, the system of the ball mill tends to be stable and the heat dissipated tends to be the same. The remaining energy is absorbed by the powder, As the ball mill speed increases, the energy generated by the ball also increases, the time required to complete the mechanical alloying process is shorter. It is found that the energy in the system will accumulate when the speed is increased or the milling time is prolonged. When the energy reaches the critical value of the powder reaction, the Ti_2SnC will be synthesized in the ball mill. It is found that with the increase of the rotational speed of the ball mill, the critical time of the reaction is gradually reduced, which is consistent with the results obtained by the kinetic mode.

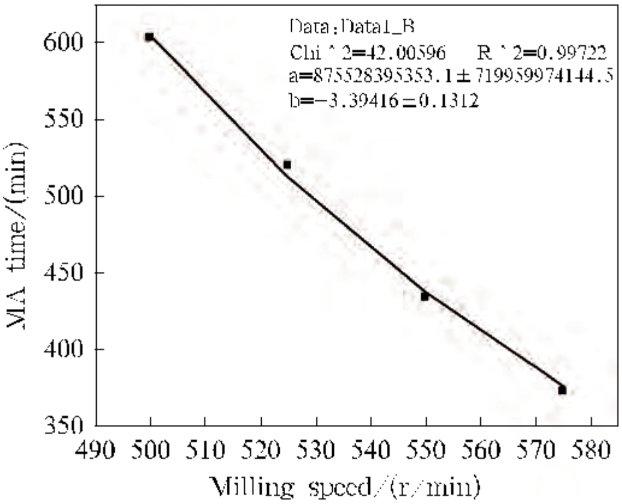

Fig.5 Relationship curve of ball milling speed and critical time

Tab.1 Corresponding for ball milling speed and synthesis critical time

Ball mill speed/(r/min)	500	525	550	575
Synthetic critical time/(min)	603	520	434	373

Tab.2 The total energy of the self-propagating reaction of powders

Ball mill speed/(r/min)	500	525	550	575
Synthetic critical time/(min)	605	526	433	371
Loss of energy per minute/(J)	1185	1234	1413	1573
Powder absorbs total energy/(J)	451786	459722	462805	476353

4. Conclusion

Through the computer simulation to determine the high-energy swing ball mill movement for the space "8" -shaped movement. Ti, Sn and C were used as reaction materials. Mechanical alloying method was used. The ball milling parameters were 500r / min, the ball diameter was Φ12 mm, the ratio of ball to material was 10 1, and the Ti_2SnC content was higher And small particles of mixed powder. The kinetic model of Ti_2SnC was established by mechanical alloying, and the relationship between the rotational speed and the critical time was calculated as $tc = 8.7 \times 10^{11}\omega^{-3.4}$.The kinetic model of Ti_2SnC self-propagating reaction and the simulation of computer simulation show that Ti_2SnC can be synthesized by self-propagating reaction as long as the powder reaches the critical energy of reaction.

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