Study on the Thermal Analysis of Solid State Nuclear Track Technique

Jianxiang Zhang

Xijing University, Xi'an Shaanxi, 710123, China

Keywords: Thermal analysis method, Solid state nuclear track technology, Trend.

Abstract. Thermal analysis method can be used to determine the solid state nuclear track of some heavy particle retention in the sample, calculate the annealing process of unit mass of the release of the heat, and in this way to measure the specific number of samples per unit mass of solid state nuclear track. This paper gives a general description of the thermal analysis method to measure solid nuclear track technique, analyzes the relationship between the energy deposition and annealing heat target, expounds the application of the basic method of the thermal analysis method.

Introduction

Currently, the researches for the thermal analysis method in academic circles is very active, the important development means of the thermal analysis of solid state nuclear track technique is to explore new measurement technology. Using the same particles shot into a solid target, if the incoming particle target dose is not high under, an incident particles can be formed a solid state nuclear track, and a solid state nuclear track can also corresponding to the corresponding number of energy accumulation, has a clear correspondence with each other the relationship between target in the accumulation of all the damage energy and the target of the nuclear track between the number. Accumulated in the target of the energy released during the annealing process annealing heat has a clear relationship with the number of target nuclear track. Based on the measurement of solid annealing unit quality of heat, the number of units of the nuclear track solid quality can be measured. Therefore, the use of thermal analysis of solid state nuclear track technique is feasible in technology. Here, the author tries to apatite unit mass of contained nuclear track number alpha particle measurement by use of thermal analysis of solid state nuclear track technique, hoping to be promoting the study.

General information about the thermal analysis of solid state nuclear track technique

Implement radioactive source radiation to the samples containing solid state nuclear track in different time periods respectively, to calculate the irradiation dose G in different time sections of irradiated samples, obtain quality of annealing heat Q in each time period of irradiation is measured after the sample unit, in Cartesian coordinates draw relationship curve between irradiation dose G and annealing heat Q, the use of linear quasi legal can be obtained by the slope of the line a, i.e. annealing heat radiation dose ratio； Intercept B, that corresponds to the tested samples annealing heat Q0, such a way can calculate the to be measured samples have been irradiated at the dose of G0=b/a=Q0/a. density of the samples with nuclear track is P0 (p0=G0/E). Since the samples for the same target, by the same type and energy particle irradiation, so measuring the numerical for samples have not been known radioactive source radiation before mass unit of the nuclear track number is to be measured. This sample is not suitable for the introduction of linear fitting method; it should be used to analyze the fitting coefficient. Notes during the measurement of nuclear track number in the apatite should endeavor as following: First of all, it should be in a bowl to grinding apatite, and then divided the sample into several experiments to ensure that the particle size distribution of each sample is uniform. Secondly, make sure use the same instrument. To use the same scanning rate of the number of samples to be scanned, each time the process of scanning the sample quality should be as close as possible. Finally, the instrument should be adjusted before the measurement. The method of verifying

the instrument condition is to carry out the test of the same sample for more than three times, and the result of the experiment has been repeated for many times.

Analysis of the relationship between energy deposition and annealing heat in the target

Radioactive source of 2 x 105 Bq was used to illuminate the source of sodium feldspar. The average energy emitted by the radiation source is about 5.1MeV. The main components of the irradiated samples are AlSi2O8, and sample is a higher content. Put the sample into the agate bowl, adding anhydrous alcohol, grinding into fine powder, and then divided into two parts, one of them is not affected by irradiation of radiation source, and the other a accepts the irradiation, the quality of irradiated samples is 40 mg, irradiation time reached 133 days. Then use delta thermal analysis system of differential scanning calorimetric to analysis the heat of the implementation, to measure the annealing heat to 26.14 J / g, has not been irradiated samples annealing heat 0.81J/g. Therefore, the annealing heat of received radiation source irradiation is about 30 time higher than the annealing heat f samples without radioactive source irradiation, it made very clear reflecting on the cumulative energy of radiation damage ,and easy to be measured by thermal analyzer . On this basis, we can further explore the relationship between energy deposition and annealing heat in the target. First, the samples were collected, and conducted annealing treatment. That is, the use of heating furnace at 800 DEG C be annealed for one hour, take 4.06 Mg from the sample after annealing, and then heated the sample with thermal analyzer to 900 DEG C, after annealing the samples of nuclear track will all disappear. If the irradiated samples were irradiated with a source of radiation after annealing, the annealing heat released by the irradiated samples is the result of radiation damage energy release. Take 5 copies from the samples after annealing treatment, which will be a quality for 220 mg per sample, use radioactivity 3.221 * 10Bq radiation source irradiation 60H, then use differential thermal analyzer to repeat three times and measure annealing heat of the same sample for three times. To reduce the man-made error as much as possible, during the experimental process, the sampling quality should be kept as far as possible the same to ensure that every time the sampling quality can be more close to each other, the samples of the three measurements with the same scan rate. The results are 14.55 13.26 and 13.43 J / g, as a result can be calculated annealing heat to occupy the proportion of irradiation dose was 56%, 51% and 52%. The results of above three measurements show that it is better to measure the annealing heat of the same sample. In order to obtain a more universal law, the other four samples is used for an additional source of radiation sources in different time periods of irradiation, irradiation time is 839, 597.5, 87, and 63h. After irradiation or differential thermal analyzer was used to measure the annealing heat, the measured values were 17.61, 12.72, 1.912 and 1.195 J/g, as demonstrated by the radiation damage of the deposited energy is very obvious. It should be said that the annealing heat and irradiation dose has a good corresponding relationship. The dose of irritation will directly determine the number of units in medium volume of solid state nuclear track. Reasoning can be conducted that there is pretty good corresponding relationship between the annealing heat in medium mass and the quality of the number of unclear track units.

The basic methods of thermal analysis of solid state nuclear track technique

For values of annealing heat as measured by the same sample may vary with the sample processing, such as abrasive particle size, and may also related to the choice of instruments, sampling tests and scanning speed. In to reduce the man-made error as much as possible, samples should be put in to the agate bowl, adding anhydrous ethanol and grinding into powder, divided into two equal portions. One of them measures the annealing heat by direct using of analysis method thermal. A second one is annealed, subsequent reuse and formed new samples for the nuclear track with a radioactive element intensity of radiation source on the second sample implementation of irradiation. The dose of irradiation can be controlled by adjustment of irradiation time, has always been to control to make the second sample which formed the nuclear track annealing heat and the first of the annealing heat consistent with each other. To be fully focused on measuring the annealing heat, both

of two samples should maintain exact same selection of instrument, test sample number, scan rate should as far as possible the same, for the second sample per unit mass of the nuclear track number can calculated according to the radiation source strength, irradiation time and the sample quality. To first samples per unit mass of nuclear track the number of copies and the second is kept equal. This way, can not only measure the number of samples of the nuclear track, but also reduce the artificial error.

For the direct measurement of the sodium feldspar, the annealing heat is 0.81J/g. If the above annealing heat is 238U appears alpha decay nuclear track cumulative energy to generate, the average energy of every alpha ion for 4.19MeV launched into the target when the energy above will be deposited in the target, during annealing, with 56% of energy will annealing heat to be released, so it can be calculated per unit mass of nuclear track number reached 0.81/ (4.19 x 1.6 x 10 - 13 x 56%) =2.158 x 1012 A / G. In this way we can calculate the 1cm3 track number reached 5.719 x 1012 A / cm3. Alpha ion nuclear track length is usually to 20 mu m is to be evaluated, 1 cm2 area of alpha ion nuclear track number reached 20 m x 5.719 x 1012 /cm3= 114.4 x 1010 bar / cm2. On the basis of fissile isotopes 238U alpha decay track number and spontaneous fission track contrast 2.22 x 106. In this way it can calculated spontaneous fission track number reached 5.153 x 103 / cm2. The results indicated to the measurement of solid state nuclear track usually generic forms. In fact, the unit mass of nuclear track use form can also be used directly.

The prospect of the development trend of solid state nuclear track technique

In the studies of solid state nuclear track technique, a gradual approach can be adopted to the implementation of the practical application of solid state nuclear track technique. The first is to confirm the conditions for the formation time and experience on environmental samples, then explore application of artificial materials factors, such as the formation of nuclear track, nuclear reactors, spacecraft materials, spacesuit materials, satellite manufacturing materials and space station materials belong to the vast majority of artificial materials; the development time is relatively short, experienced by the environment is relatively clear, it can be simulated in the laboratory by cosmic ray irradiation thermal analysis curves before and after the space flight after being subjected to thermal analysis curves after cosmic ray irradiation compared to that by the actual situation of the above material injury. Early stage of cosmic rays in the main ingredients for protons and alpha particles, the resulting damage track is very suitable to be measured by thermal analysis method, and in the past often use chemical etching method will by recording threshold constraints, these studies cannot be implemented with natural materials. Of course, the use of analysis method thermal also conducted into geological exploration. Using the neutron bombarding heavy nuclei will lead to the fission, fission will leave corresponding nuclear track in solid, some researchers proposed to measure after fission in the solid leave the nuclear track annealing heat to obtain neutron source is in the midst of flux. At the same time, we should also actively conduct researches on all kinds of natural samples. The nuclear track in Combustion products of is often gradually formed after the burning. Using this method can also determine its dating and geological age and so on. In order to guarantee the heart we measured is the pure nuclear track annealing heat; corresponding measures should be adopted to exclude the influence factors for the formation of other heat effect. Thermal analysis method is often based on the curve of the thermal effect of the temperature range and the difference between the temperature points to distinguish the cause of heat effect. This method can be used for distinguishing elements and water oxidation, carbon dioxide, sulfur dioxide emission generated. In addition to above mentioned, the following method can also be used, the sample will be compared before and after irradiation, analyzed the back hot curve of the milled samples before and after in subjected irradiation, analysis curves of inquiry of the milled samples before and after the thermal, analysis curves for comparison of the samples by stress before and after the thermal, to examine what the heat effect zone and nuclear track back hot effect zone appears to coincide. Once there is a coincidence, it means the

non nuclear track annealing factors seriously affect to the nuclear track annealing measurements of the heat. Then an itemized analysis will be conducted until such error is corrected.

Conclusion

In conclusion, nuclear track of solid state in the medium energy deposition is obvious, this energy suitable to measure by thermal analyzer, and measurements of energy and medium nuclear track number have very good corresponding relationship. So, we can use thermal analysis method to explore the medium of nuclear track number and the samples for application of the measuring method are extremely broad. As far as the theory is concerned, the result of the measurement is much better than that of the dominant position of the microscope. In author's opinion, as long as the continuous improvement, perfecting and exploring new measures of solid state nuclear track observation and keep record of it, the implementation of the thermal analysis of solid state nuclear track technique can find a new path for the study of nuclear tracks in solids. As a result, to further promote the development of the thermal analysis of solid state nuclear track technique has great significance meaning. At the same time, when thermal analysis method for measuring solid state nuclear track technique is more mature, it can also applied to nuclear physics, interstellar space particle, meteorites, old track and fission track ages of measurement, environmental science and so on many disciplines, to play a greater research value.

Acknowledgments

Fund name of this article: determination of heat release characteristics of geological samples by thermal analysis method. NO.:XJ150127.

References

[1] Zhu Runsheng. Solid state nuclear track detector principle and application. Beijing: Science Press, 1987.

[2] Luo Yisheng, Zhou Yu, Wang Xinggong. Automatic measurement system and the main application, *Nuclear technology of solid state nuclear track*, 2002 (7).

[3] Guo Shilun. Experimental discrimination of the threshold origin of the solid bubble damage detector, *Nuclear technology*, 2002 (7).

[4] Chen Ling, Liu Senlin, Yi Hua Wu. Solid state nuclear track detector for radon calibration coefficient and the atmospheric pressure influence of Monte Carlo simulation, *Atomic energy science and technology*, 2004 (1).

[5] Ju Yong Lin, Gu Yan. Low temperature phase detection of low energy solar neutrino detector global, *Science Bulletin*, 2007 (52).

[6] Zhang Labao, Kang Lin. Superconducting infrared single photon detector, *Chinese Science Bulletin*, 2008 (53).