ty1 and also increasing the economy of each country offering a thousand of jobs.

Year by year the consumption is increasing. While a lot of rather developed countries do not pay much attention to the amount of municipal solid waste (MSW) they are producing, countries like USA and Germany are changing the rules of this game. They are aware of the issue and recycle tones of MSW that are produced day by day. Russia recycles 4-5% of its MSW total, but in comparison to Germany which makes up 56% of its MWS, it is definitely not enough. Russia clearly is out of this massive business that can help and change the way we see a simple aluminum can. Clearly, it would be quite complicated for any country to change its rules of dealing with this problem to enter the game of the business of the MSW.

How can Russia become a part of this game? As it's proved in other countries, adding extra taxes to the products which produce more MSW have a positive reaction among the people, because it makes them stop buying these types of products. Another option is sorting the garbage to obtain their taxes "back". That is the most complicated and challenging part for all the countries that are trying to be a part of the ambitioning business of the garbage. As the evidence, we can say that the industry makes more than $800 million annually and this is only by recycling aluminum cans. If we considered forcing the recycling a big part of ours wastes, we could earn a big amount of money which would also benefit the job market and create many opportunities and work positions.

Volatility 1 – Financial market volatility simply refers to changes in asset prices over time and is partly due to uncertainty.

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POSITRON ANNIHILATION TECHNIQUE IN HYDROGEN STORAGE MATERIALS

Abstract

The feasibility of using the positron annihilation methods is discussed.

Two main methods of electron positron annihilation – positron annihilation lifetime spectroscopy and coincidence Doppler broadening are used to characterize the materials – hydrogen accumulators.

Introduction

The use of new technologies that do not produce CO_2 has become central to the agenda of many signatory countries at Paris Conference in 2015 [1]. Many countries have adopted directives on how to reduce CO_2 emissions [2], [3]. According to these plans, hydrogen as a energy carrier is to meet part of the energy needs of fossil fuels [4],[5],[6]. There are currently several methods for hydrogen storage [7]. The one method for hydrogen storage is compressed hydrogen under the high pressure of 300-700 bar in the gaseous phase. Hydrogen is also stored in the liquid phase. By means of physical adsorption it is possible to bind a certain amount of hydrogen on the surface, usually porous materials are used as they have large surface area available for adsorption. Hydrogen reacts with most of the transition metals forming hydrides. The other method for hydrogen storage is chemical reaction in solid and liquid phases. The materials interacting with hydrogen are considered in this paper.

These methods enable to study hydrogen impact on materials properties [8]. Positron lifetime spectroscopy (PLS) and Doppler broadening spectroscopy (DBS) are discussed in this paper.

Methods for materials characterization

1. Positron lifetime spectroscopy (PLS)

Positron lifetime spectroscopy is the technique that measures the life of a positron between its formation by nuclear reaction, production of positron and emissions of two gamma quanta caused by the electron-positron annihilation. The lifetime of positron is caused by the density of the surrounding electron cloud [9]. This property of positron enables using this technique to record defect conditions and determine the type of defect [10]. The standard source used in this technique is the isotope ^{22}Na, figure 1, but there are some other isotopes that can be used [11]. It is usually deposit in the form of NaCl compounds on a Kapton or metal foil with the thickness in the micrometer scale. After deposition, it is placed between two plate samples to be tested by this method.

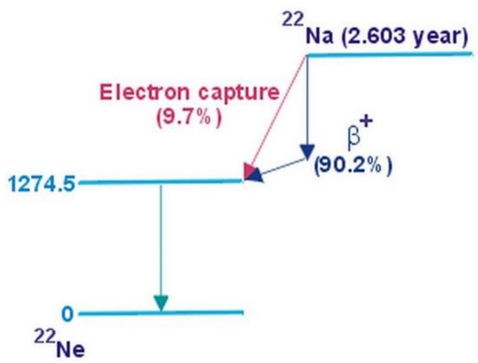

Figure 1. Decay scheme of isotope 22Na [12]

The source of ^{22}Na generates about 0.92 positrons per decay. It should be emphasized that due to the thickness of the foil to which the radioactiveisotope is deposited, the positron flux decreases due to absorption with the foil. Therefore, the number of available positrons is smaller by a certain value which can be calculated [13,14]. Another important feature of this method is the need for the sample to be of a certain thickness in order for all available positrons to interact with the sample, so that the positron does not pass through the sample without interaction. The thickness of the sample depends on the characteristics of the sample and energy of emitted positrons by source [15]. A positron that has energy on the MeV scales dominantly loses energy through bremsstrahlung. On the keV scale over Moth scattering, while at lower energies there are several tens of keV interactions with phonons. In case the thermalization is done with electron cloud, it takes about 1 ps, and if it is done with phonons, it lasts up to 12 ps [16].

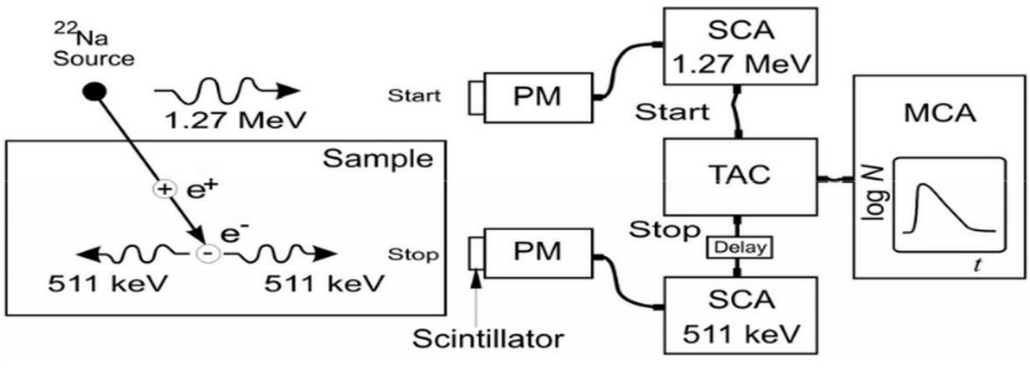

Figure 2. Scheme of positron lifetime spectroscopy technique in fast-fast coincidence mode. PM – Photomultiplier tube, SCA – single channel analyzer, TCA – time to amplitude converter, MCA - multi-channel analyzer [15]

Figure 2 shows a schematic representation of the PLS apparatus in the fast-fast coincidence mode. After the emission of positrons by the ^{22}Na nucleus, there was formed the excited level of the nucleus ^{22}Ne which live 3 ps after that time with the emission of gamma photons of energy of 1274.54 keV, it goes in ground state. Comparing this time and the lifetime of the positron, it is concluded that the decay occurred without delay. The upper scintillator detects the gamma photon emitted by the positron source, after which the timer is turned on. While the lower detector detects the gamma photon formed after the electron-positron annihilation, then the timer stops. The time elapsed between these two events is read and taken as the positron lifetime. Based on this time, we obtain data on the type of positrons interaction with the solid material. The rest of the scheme represents the electronics by which the given signals are processed and recorded. In addition to the previous mode, there is a fast slow coincident mode in which SCA works in a microsecond interval using a side channel with integrator and spectroscopy amplifier. This mode is used when more precise pulse height information is needed.

Doppler broadening spectroscopy (DBS)

This technique is based on the Doppler shift of gamma lines that occurs during the decay of the positronium given by the relation 1.

$$\Delta E = \frac{c \cdot p_L}{2} \quad (1)$$

With p_L denotes the longitudinal momentum of a gamma photon and c denotes the speed of light.

Since almost all positrons have the value of thermal energy at the moment before they form a positronium, the moment that a gamma pair of photons has is derived only from the moment of the electron. This moment is the cause of the 511 keV Doppler broadening line. Depending on the moment value, the positron interacts with valence electrons, which have a low moment value, or with electrons from the lower shells, which have a higher moment value [17].

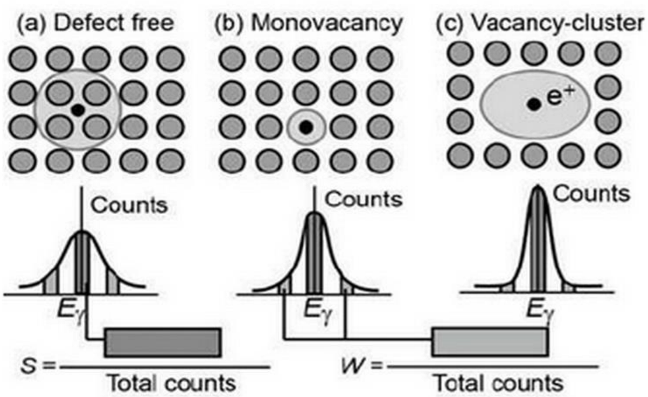

Figure 3. Scheme of Doppler broadening spectrum [18]

Each atom has precisely determined energy levels at which the electrons have a precisely defined moment; it is possible to perform chemical analysis by interacting with electrons on lower shells. The consequence of this is that each material has a unique curve shape on the 511 keV line.

It is important to emphasize here that this interaction is less likely than the interaction with valence electrons.

After measurement is finished and the shape of line on 511 keV is obtained, the procedure for analysis starts. We have two integral values W and S; the procedure is given in figure 3. It is possible to observe on which way is changed shape on line base on type of defect. Comparing the shape of line on 511 keV form measure no defect was found and it is possible to make conclusion about volume of defect in material.

When designing the system, the fast-fast coincidence mode is used if events that are rare recorded, or a self-set Ge detector is used if the events recorded are strong and above the noise. Figure 3 shows the both setups.

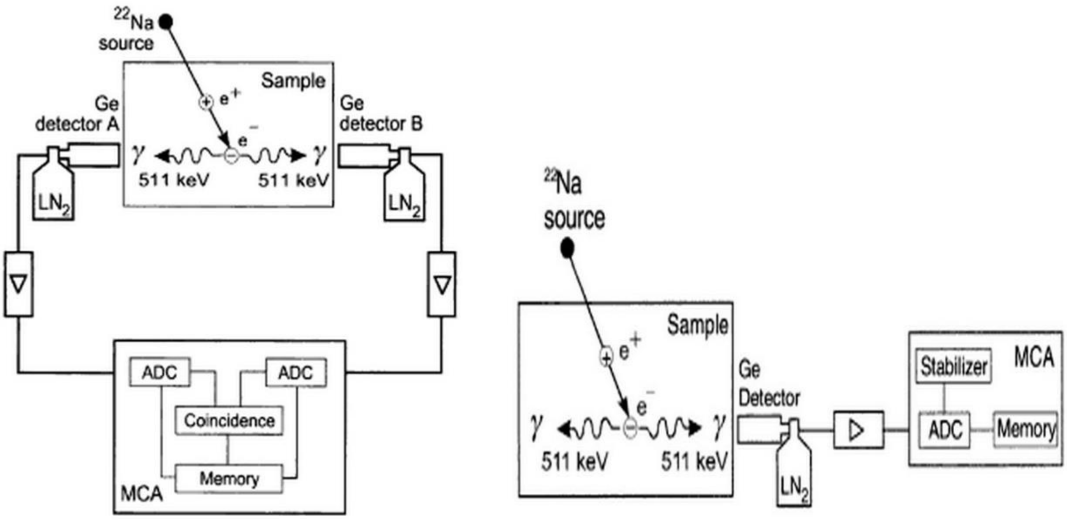

Figure 4. Scheme of Doppler broadening spectroscopy technique fast-fast coincidence mode and in single mode. MCA - multi-channel analyzer and ADC - analog digital converter [19]

Conclusion

Using these two techniques,it is possible to analyze defects in materials and determine the chemical composition of atom itself and surrounding atoms and molecules. Defects play significant role in hydrogen sorption in solids. Hydrogen forms strong bonds with defects; this limits hydrogen desorption and using materials as hydrogen accumulating materials. Defect structure determines hydrogen sorption-desorption cycle in solids. Positron annihilation methods enable to estimate hydrogen interaction with material storage candidate for industrial applications.

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SYNTHESIS OF ZEOLITES FROM RAW MATERIALS

Zeolites are aluminosilicate materials, and its properties are determined by the interaction of the two main minerals in composition: silicon (Si) and aluminum (Al). [1-3] The Si / Al ratio in its oxide forms (SiO_2 / Al_2O_3) determines the possibility of the formation of specific zeolites, since each type