REVERSIBLE MEDIUM FOR RECORDING AND STORING INFORMATION BASED ON VANADIUM DIOXIDE V_2O_5

[1] Gaibnazarov B.B., [2] Tursunov M.A., [3] Tajibaev A.T., [1] Khojiev Sh.T., [2] Kosimov I.O.
[1,2,3]TashSTU, Tashkent city, Universitetskaya street, [1,2]Institute of Bioorganic Chemistry named after acad. O.S. Sodykova AS RUz

https://doi.org/10.5281/zenodo.7541666

Abstract. *X-ray diffraction analysis of materials is a standard method for phase identification and characterization of polycrystalline materials [1]. Experimentally, various peaks were detected in the X-ray phase analysis (XRD) spectra of vanadium penta oxide V_2O_5. Based on the data (XRD) of sample of vanadium penta oxide V_2O_5 obtained for samples with different modes of powder production, Miller indices and lattice parameters were determined. The experimental data obtained are in good agreement with the data obtained by other methods.*

Keywords: *vanadium penta oxide, powder, wide-gap semiconductor, Miller indices, microstructure.*

Introduction

In this work, the powder X-ray phase analysis method was used to study the structure, composition and properties of the raw material of a sample of vanadium pentoxide obtained under various conditions. Mineralogical [1] and phase compositions [4] were studied with its help. The study of the physicochemical properties of vanadium oxides is of considerable interest from the point of view of micro and nanoelectronics. In particular, a sharp and reversible change in the physical properties of vanadium dioxide during the metal–semiconductor phase transition in combination with interference phenomena in thin films makes it possible to use this material as a reversible medium for recording and storing optical information, controlled mirrors with variable reflection, visualizers and detectors of IR and microwave radiation and other devices [1]. In addition, [2] reports on the production of highly sensitive and effective bolometers based on vanadium oxides — both V2O5 and higher oxide (V2O5), as well as films representing a mixture of VO2–V2O5 phases. In the latter case, the most successful combination of optical and electrical properties of the material can be achieved, which is necessary to optimize the parameters of IR detectors. The amorphous V2O5 also exhibits an electrochromic effect [3], which is used in electrochromic displays, controlled filters and optical media with variable light transmission (”smart windows”) [2]. One of the convenient ways to obtain thin films of metal oxides is electrochemical (anodic) oxidation. Anodic oxide films are, as a rule, structurally disordered, and their stoichiometry (during oxidation of transition metals with variable valence) corresponds to a higher oxide. However, in the case of anodic oxidation of vanadium, the phase composition of the oxide film is identified in some works as V2O5, and in others as VO2 or a mixture of V2O5 with lower oxides (see, for example, [3] and references there). Preliminary results were reported in [4] showing that the phase composition of vanadium anode oxide can be controlled by the choice of appropriate oxidation modes and conditions (electrolyte composition, anode current density, anodizing time), i.e. oxygen stoichiometry of the oxide film can be varied from VO2 to V2O5.

Research methodology

Powder X—ray diffraction is a method of studying the structural characteristics of a material using X-ray diffraction (X-ray diffraction analysis) on a powder or polycrystalline sample

of the material under study. Also called the powder method. The result of the study is the dependence of the scattered radiation intensity on the scattering angle.

The corresponding device is called a powder diffractometer. The advantage of the method is that the debaegram for each substance is unique and allows you to determine the substance even when its structure is not known. The X-ray phase analysis method was used to study the structure, composition, properties of raw materials and firing products. Mineralogical and phase compositions were studied with its help [5]. A monochromatic beam of X-ray radiation is directed to a sample of the test material, ground into powder. On a photographic film rolled up by a cylinder around the sample, the image (debaegram) is obtained in the form of rings. The distance between the lines of the same ring on the debaegram allows you to find the Bragg angles of reflection. Then, using the Bragg–Wolfe formula $2d \sin\Theta = n\lambda$, we can obtain the ratio d/n of the distance between the reflecting planes to the order of reflection.

X-ray analysis allows you to solve the following tasks: Determination of the qualitative composition of the sample, semi-quantitative determination of the components of the sample, determination of the crystal structure of the substance. As well as precision determination of the unit cell parameters, determination of the location of atoms in the unit cell (full profile analysis — Rietveld method), determination of the size of crystallites (coherent scattering region) of a polycrystalline sample. Study of texture in polycrystalline materials. In addition, the study of the phase composition of the substance and the study of state diagrams, the estimation of the size of crystals in the sample, the precise determination of lattice constants, the coefficient of thermal expansion, the analysis of minerals. Fig.1. shows a device - a powder diffractometer.

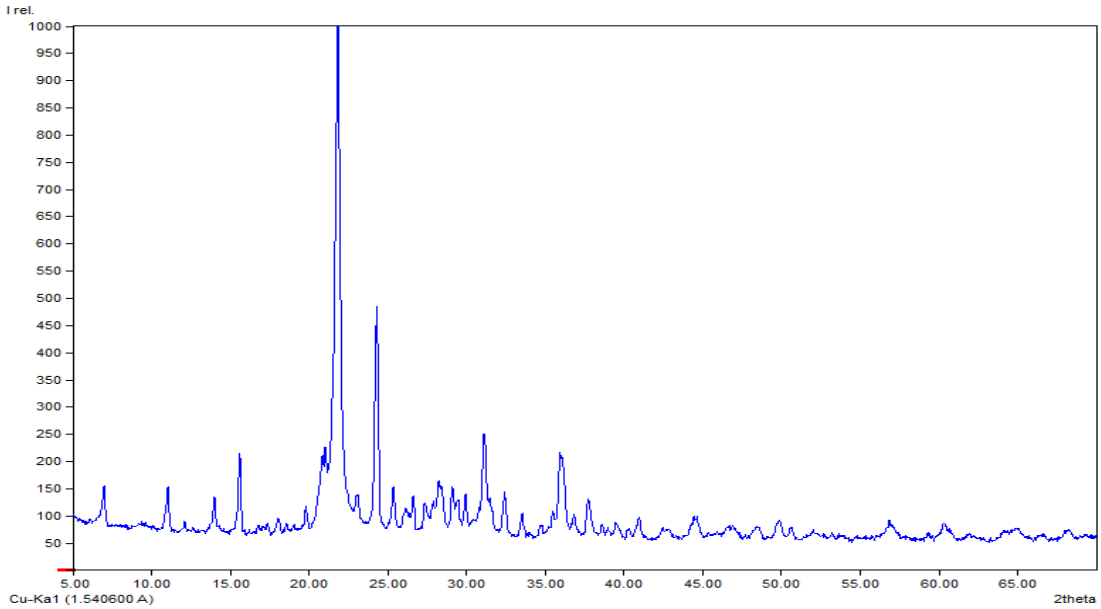
Fig.1.

Powder X-ray diffractometry. XRD-6100. Main results and their discussion

This paper presents the results of a study of the optical properties of vanadium pentoxide. The studied samples were obtained by anodic oxidation of vacuum-sprayed layers of metallic vanadium on quartz, glass and citall substrates. Two different oxidation modes were used [4] and, accordingly, two types of samples were obtained: practically stoichiometric VO2 (type I) and films with an increased content of phase V2O5 (type II). Measurements of transmission T and reflection R were carried out by the spectrophotometric method in the range λ from 300 to 2000 nm.

Fig. 2.

Diffractogram of a sample of vanadium pentoxide V2O5.



To study structural changes in the electrochromic effect, samples of vanadium pentoxide films obtained by sol-gel method on a glass substrate were radiographed in symmetrical geometry for reflection on an XRD-6100 diffractometer in automatic mode. Cu radiation (λ = 1.540600 Å) was used, monochromatized by a pyrolytic graphite crystal mounted in reflected rays. The survey was carried out in the range of scattering angles from 2 to 80 degrees. The shooting step is 0.5° the shooting time of each point is 25 seconds. The X-ray power was 2 kW. The calculation of the interlayer distance was carried out using the Wolf-Bragg formula, the scattering angle 2 was determined on the basis of the obtained radiographs. The results were analyzed using a database [6]. The penetration depth of Cu-Ka radiation is about 1 mm (980 microns) for light elements (carbon), and several microns for heavy elements (Ag, W). For most inorganic substances, simple compounds, Cu-Ka- is tens of microns (microns). Using this method, we determined the dhkl interplane distance and Miller indices (hkl). For a sample of vanadium pentoxide- V2O5 measured by X-ray diffraction analysis using the “Search and Match” software technique [6], the degree of crystallinity and amorphousness was evaluated. The amorphous phase for vanadium pentoxide V2O5 is - 77.36%, the crystalline phase is only -22.64%. This indicates that our film is mostly amorphous.

Conclusions

To study structural changes in the electrochromic effect, samples of vanadium pentoxide films obtained by the sol-gel method on a glass substrate were radiographed in symmetrical geometry for reflection on an XRD-6100 diffractometer in automatic mode. Cu radiation (λ = 1.540600 Å) was used, monochromatized by a pyrolytic graphite crystal mounted in reflected rays. Using this method, we determined the dhkl interplanar distance and Miller indices (hkl). For a sample of vanadium pentoxide- V2O5 measured by X-ray diffraction analysis using the “Search and Match” software technique [6], an assessment of the degree of crystallinity and amorphousness was carried out. The amorphous phase for vanadium pentoxide V2O5 is - 77.36%, the crystalline phase is only -22.64%. This indicates that our film is mostly amorphous.

REFERENCES

1. Бугаев А.А., Захарченя Б.П., Чудновский Ф.А. Фазовый переход металл–полупроводник и его применение. Л.: Наука, 1979. 183 с.
2. Jerominec H., Picard F., Vincent D. // Optical Engineering. 1993. V. 32. N 9. P. 2092–2099.
3. Ord J.L., Bishop S.D., DeSmet D.J. // J. Electrochem. Soc. 1991. V. 138. N 1. P. 208–214.
4. Chudnovskii F.A., Pergament A.L., Stefanovich G.B. Anodic oxidation of vanadium. — Seventh international symposium of passivity and passivation of metals and semiconductors. Abstracts, Clausthal, Germany. 1994. P. 149.
5. Kenny N. et al. // J. Phys. Chem. Solids. 1966. V. 27. N 8. P. 1237–1246.
6. Xojiev Sh.T., Kosimov I.O., Gaibnazarov B.B. Zadachi, reshayemye s pomoshyu poroshkovoy difraktometrii.Sbornik materialov II mejdunarodnoy nauchno-teoreticheskoy konferentsii «Aktualniye voprosiy yestestvennix nauk»19 maya,.Nuks 159 (2021).