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SHORT COMMUNICATION

PREPARATION OF GaAs THIN FILMS FROM ACID AQUEOUS SOLUTION

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Gallium arsenide thin films were electrodeposited from acid aqueous solution on graphite substrates. There wer studied the effects of the following operating parameters: applied potential, current density, electrolyte composition, cathode material, deposition temperature, pH and agitation. X-ray diffraction patterns of the depositions showed a crystalline gallium arsenide thin films after annealing. Freshly deposited films are amorphous. After annealing polycrystalline GaAs and As are formed, as shown by X – ray diffraction measurements.

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Research on the production of ceramic coatings by electrochemical methods, although not extensive, has been the subject of a number of investigations [1, 2, 3]. Compared to other conventional methods, electrodeposition has the advantages of low temperature operating and equipment costs, relatively easy control of film properties, high deposition speed [4, 5].

GaAs is a candidate material for optoelectronic devices [6] and many studies have been performed up today on various properties including transport properties, recently reinvestigated by magnetoresistance measurements [7]. The aim of the research was to obtain gallium arsenide coatings by an electrolytic method. The objectives of the present research were: (a) the establishment of the conditions for the electrocoating and (b) studies which established the influence of some electrodeposition parameters on the morphology of the deposited layers.

The electrolytic cell that was used in the investigations had cylindrical symmetry. It contained an electrolytic solution, a cathode, an anode, an agitator, a thermometer and a pH-meter probe. The cathodic depositions were carried out on a 5 mm-diameter graphite cylinder. The anode was made from a 20 mm diameter spiral of platinum wire with a pitch of 2 mm. The electrolyte solution consisted of equimolar amounts of $GaCl_3$ and As_2O_3 dissolved in concentrated HCl. Deionized water was added to provide a volumetric ratio of $HCl/H_2O = 3$. The solution was colorless at low pH 2.6. The pH was adjusted with concentrated KOH solution. During the electrocoating process, it is possible to develop the evolution of small quantities of heat that lead to the development of some temperature gradients. These can change both the degree of solvation and the pH of the solution. Therefore, some reaction can occur which bring about the formation of colloidal particles of the hydroxyperoxocompound of Ga and As. The electrodeposition process can be considered to develop in four stages: impregnation, diffusion, adsorption and chemical reaction. The last two stages can be distinct or not, depending on their kinetics. After electrochemical deposition, some of the samples were annealed at high temperature in a furnace.

Fig. 1 presents the experimental data concerning the variation of the weight of deposit versus deposition time, for three current densities.

It can see that there is a small tendency in order to obtain a saturation of deposited weight when the deposit time grows for each current density taken in study. The value of deposition time, when the saturation process begins, depends of the value of current density. This aspect can be explained by the consumption of components from electrodeposition solution.

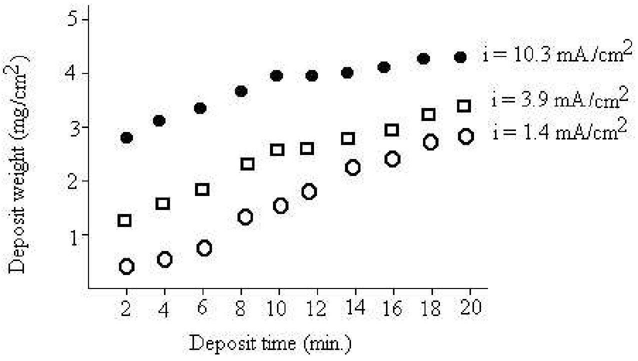

Fig.1. Dependence of the weight of deposit on deposition time.

Fig. 2 presents the dependence of the electrodeposited weight versus current density for two deposition times. The same aspects like in case of the first figure can be observed: a saturation tendency of deposited weight, for the both deposition times, when the current density increases. The dependence of deposit weight versus deposition time, can be used in thickness coating control. The influence of some other electrodeposition parameters have been carried out: effect of the deposited potential, effect of the pH, and effect of the agitation.

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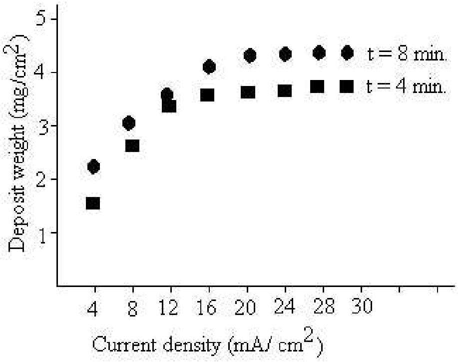

Fig. 2. Dependence of the weight of deposit on electrical current density.

Fig. 3 showns the relationship between potential of deposition and gallium content in GaAs films (electrolyte at pH = 2.6 containing 0.12 M Ga and 0.07 M As). Gallium was deposited at potentials lower than –1.1 vs. Ag/ AgCl. Gallium amount increases for more negative potentials and a white precipitate appears on the black deposit.

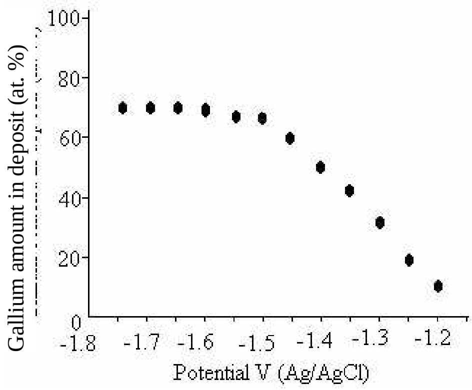

Fig. 3. Ga amount in deposit as a function of the potential V.

In Fig. 4 is presented the dependence of the amount of deposited gallium on current density for three values of pH. The pH plays an important role in the electrodeposion process, fact resulted from mentioned dependence. At high value of pH, for example between 2.6 and 3.0 gallium hydroxide readily precipitates on the cathode, particularly at high current density or very negative potential. At lower value of pH, high current density or very negative potential is necessary to obtain a thick deposit having 50% gallium content. A higher current density was accompanied with more bubbles on the cathode, produced more gallium in the deposit for a specific pH. For each pH value, there was a range of current density, which gave constant gallium content in the deposit. For a pH, i.e., between 2.0 and 2.6 and high value of current density of 50 and 70 mA/cm^2 at a deposition time of 15 min. a white precipitated was observed. At a small value of pH, i.e. of 1.0, the deposit is reached in gallium content, but it requested a very high current density of 110mA/ cm^2 and no white precipitate was observed. A good adherence of the deposit at substrate was obtained at a pH of 2.6 and a current density of 24 mA/ cm^2. In this case the colour of deposit is dark grey.

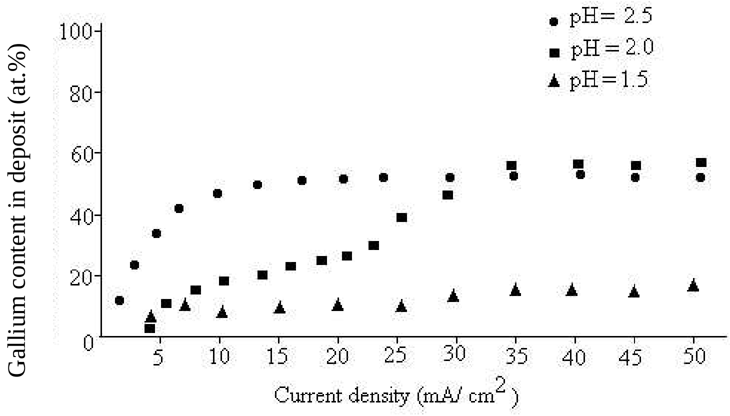

Fig. 4. Influence of pH on gallium content as a function of the electrical current density.

The X-ray diffraction study performed on DRON-3 equipment showed that the electrodeposition is amorphous. The deposit, having a thickness of 0.26 µm, obtained at a pH of 2.6, i = 15 mA/cm^2 and a solution with 0.15 M Ga and 0.08 M As, was subjected to a thermal treatment consisting in an annealing at 300 °C during eight hours. Fig. 5 shows the X-ray diffraction pattern of the deposited film. The characteristics peaks of GaAs as well as those of metallic arsenic are evidenced.

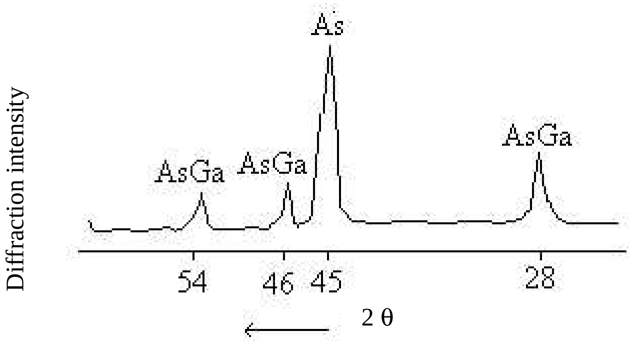

Fig. 5. X-ray diffraction pattern of GaAs thin film after annealing.

Gallium arsenide thin films have been got by electrodeposion process from acid aqueous solutions. The experimental conditions strongly influence the quality of the electrodeposition. The pH of solution and current density can be controlled a thin film having a high adherence is obtained. The

X-ray patterns show that the electrocoatings are in amorphous state. After annealing the films become crystalline. The optimal electrochemical parameters that lead to a film with a high adherence and chemical stability are pointed out.

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