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SPECTRAL ANALYSIS AND ITS APPLICATION IN MODERN MICROELECTRONICS TECHNOLOGIES

СПЕКТРАЛЬНИЙ АНАЛІЗ І ЙОГО ЗАСТОСУВАННЯ В СУЧАСНИХ ТЕХНОЛОГІЯХ МІКРОЕЛЕКТРОНІКИ

Gorbachuk N.T. / Горбачук М.Т.
PhD,c.p.m.s, as. prof. / канд. ф.-м. наук, доцент
ORCID: 0000-0001-6059-2464
Ostrozhinsky V.E. / Острожинський В.Є.
student / студент
Kyiv National University of Technologies and Design (KNUTD)
Nemyrovycha-Danchenka Street, 2, Kyiv, 01011
Київський національний університет технологій та дизайну (КНУТД)
вул. Немировича-Данченка, 2, Київ, 01011

Annotation. *The paper briefly discusses the main modern methods of spectral analysis. The application of mass spectral analysis to determine the elemental composition of Ge films on GaAs substrates is shown. The concentration levels of Ga and As in these films were determined.*

Keywords: *spectral analysis, microelectronics, germanium films*

Анотація. *В роботі коротко розглянуто основні сучасні методи спектрального аналізу. Показано застосування масс-спектрального аналізу для визначення елементного складу плівок Ge на підкладках GaAs. Встановлено рівні концентрації Ga та As в цих плівках.*

Ключові слова: *спектральний аналіз, мікроелектроніка, плівки германію*

Introduction

In a huge number of modern technologies, there is a need to know with varying accuracy the elemental composition of the materials used. This is especially relevant, for example, in the technologies of heteroepitaxial production of structures for microelectronics /1,2/. Here, problems may arise associated with the mutual penetration of atoms of the heterostructure and autodoping. Currently, various methods of spectral analysis are most often used for this purpose /3/. Based on the knowledge of the principles of operation and the capabilities of the methods, it is possible to establish the applicability of the method for the corresponding task.

Main section

Spectroscopic methods of analysis are based on the ability of atoms and molecules of a substance to emit, absorb or scatter electromagnetic radiation. It is worth noting that the methods and methods of spectral analysis of the elemental composition of matter became possible after the experimental and theoretical study by physicists of the structure of atoms and molecules of matter and the creation of models of the structure. When talking about spectral analysis used in microelectronics technologies, they most often mean the analysis of the elemental composition of the materials used – semiconductors, metals, etc. For this purpose, such well-known methods and methods of spectral analysis exist and are being developed, which distinguish by the nature of the interaction of electromagnetic radiation with the analyzed substance and the state of the substance. For example: emission spectroscopy, luminescence spectroscopy, absorption spectroscopy, nephelometry, diffuse reflection spectroscopy, atomic spectroscopy, molecular spectroscopy, etc. Recently, emission and mass spectrometric methods of spectral analysis have become the most widespread.

Mass spectrometry (mass spectrometric analysis) is also referred to as spectrometric methods, although, strictly speaking, there is no interaction of matter with electromagnetic radiation at the heart of the method. But the appearance of the graphical distribution of ions by mass numbers - the dependence of the ion current intensity on the mass-to-charge ratio - resembles a spectrum. It was called mass spectrum, and the method itself is mass spectrometry. This is one of the best ways of qualitative identification of substances and quantitative determination. The method is based on the ionization of atoms and molecules of a substance and the subsequent separation of the resulting ions in accordance with their mass number m / z - the ratio of the mass of the ion to its charge. The separation occurs in an electric or magnetic field in which these ions move. We can say that mass spectrometry is the “weighing” of the molecules in the sample under study.

The advantage of the method is that a very small amount of substance is sufficient for analysis. The disadvantage of the method is that it is destructive, i.e. it is not the sample of the substance itself that is being investigated, but the products of its transformation. At the same time, the destruction may be insignificant and depends on one or another method of ionization of the substance.

Ionization methods:

- spark electric discharge
- laser radiation
- the flow of primary accelerated ions

Accordingly, the name of the analysis methods also arises:

- spark mass spectrometry

- laser mass spectrometry
- ion or mass spectrometry of secondary ions.

By considering and studying this or that method, you can determine its advantages and disadvantages when using it to solve specific problems that arise. To determine the elemental composition of germanium films on gallium arsenide, the method of mass spectrometric analysis was used /4/. The main goal was to determine the number of gallium and arsenic atoms in these films. These elements, under certain conditions, can transfer from the gallium arsenide substrate and intensively dope the film. For example, when Ge films with a thickness of 3 microns were obtained at a deposition temperature of 500 ºC, it was found that the content of gallium and arsenic was at the levels of 0.1% of the composition. The relative content of these elements in the films also depends on various other conditions of the production technology (annealing of the substrate, vacuum, etc.).

Table 1. Relative content of gallium and arsenic in layers of Ge-GaAs heterostructures

N_{Ga}/N_{Ge}		
Outgoing GaAs	Films n-Ge	Films p-Ge
0,45	1,3	2,7

Table 1 shows the relative content of gallium and arsenic in the initial gallium arsenide and germanium films on it of various types of conductivity. It is established that gallium and arsenic diffusing from the GaAs substrate can significantly affect the properties of films and determine them, including the type of conductivity.

Conclusions

The principles of operation of the main methods and methods of spectral determination of the elemental composition of a substance are considered. The relevance of analysis methods for modern microelectronics is shown. The possibilities and results of determining the elemental composition of germanium films on gallium arsenide using mass spectral analysis are presented.

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