

## **REVIEW**

of the Ph.D. thesis of Fedir Oleksandrovych Yevtushenko "Resonant scattering and absorption of electromagnetic waves by infinite gratings of graphene strips on dielectric substrates", the field of knowledge 10 — Natural Sciences, specialty 104 — Physics and Astronomy

### **Significance of the research.**

Graphene is a promising material for electronics and nanoelectronics, primarily due to its high electronic conductivity, which can be controlled by changing its chemical potential using external electromagnetic fields. Therefore, the study of structures containing graphene films forms the contemporary problems of radiophysics and electronics. The investigation of F. Yevtushenko belongs to such studies. It considers the two-dimensional problems of scattering and absorption of plane waves incident on infinite periodic gratings of graphene strips located on a dielectric substrate in the case of E and H polarizations.

The problems are solved by the Riemann-Hilbert technique in the case of H polarization, and by the method of the inverse discrete Fourier transform method in the case of E polarization. In both cases, the Fredholm equation of the second kind is obtained. In addition, the eigenvalue problem for the considered problems in the laser formulation was solved, i.e., threshold values of substrate gain for the modes of the gratings were found.

The correct formulation of boundary value problems and the use of rigorous mathematical methods for their solution is a strong point of the work.

### **The main new results of the thesis:**

- Algorithms for solving scattering and eigenvalue problems for periodic gratings of graphene strips on a dielectric substrate were built and comprehensively tested for reliability and convergence.

- Resonance effects that occur during the scattering of a plane wave by the gratings were identified and investigated. In particular, new resonances were found, which are caused by the presence of a dielectric layer.

- The effect of electromagnetically induced transparency, which can be obtained by controlling the chemical potential of graphene in the case of H polarization, has been revealed.

- The field distributions of the grating modes were studied, and threshold values of the substrate gain, ensuring the laser mode of operation of the structures, were identified.

The **reliability** of the obtained results is confirmed by comparison with known results for gratings of resistive strips.

The results of the thesis are fully presented in five papers published in high-ranking foreign journals with quartile Q2 and Q3.

#### **Critical assessment of the work:**

The first item of the list of new results states "... thicker and denser substrates request solving larger matrices for the same accuracy." This item requires rewording. Since, in this case, it is incorrect to use the word "dense" to denote a higher dielectric constant. In addition, the results shown in fig. 2.3, do not demonstrate a significant influence of the dielectric thickness on the convergence of the algorithm.

The main part of the thesis is written in proficient English, but there are some comments on the abstract in Ukrainian. In particular, it is better to use the word "приводить" instead of "призводить", as the last one has a negative connotation. (pages 9, 10). Instead of the word "співпадає" it is better to use the word "збігається" (p. 10). The word "переналаштовується" is written together without a hyphen (p. 11).

#### **Conclusion on compliance of the thesis with the norms.**

I believe that F. Yevtushenko's thesis "Resonant scattering and absorption of electromagnetic waves by infinite gratings of graphene strips on dielectric substrates" is a completed scientific work that contains a number of new, relevant and reliable results. The thesis fully complies with the requirements of the Order of the Ministry of Education and Science of Ukraine No. 40 of 12.01.2017 "On Approval of the Requirements for Dissertations" (with subsequent amendments)

and "The Procedure for Awarding the Doctor of Philosophy Degree and Revoking the Decision of the One-time Specialized Academic Council of a Higher Education Institution, Scientific Institution on Awarding degree of Doctor of Philosophy", approved by the Resolution of the Cabinet of Ministers of Ukraine No. 44 of January 12, 2022.

The mastery of rather complicated mathematical methods by the Ph.D. candidate, the consistency and comprehensiveness of the research, along with the obtained new results confirm the qualification level of F. Yevtushenko, sufficient for awarding him the scientific degree of Doctor of Philosophy in the field of knowledge 10 "Natural Sciences", specialty 104 "Physics and Astronomy".

Reviewer, Doctor of Physical and Mathematical Sciences,

Senior researcher,

Head of the Laboratory of Computational Electromagnetics of  
the Department of Diffraction Theory and Diffraction Electronics,

O.Ya. Usikov Institute for Radiophysics and Electronics NASU

Sergiy STESHENKO



The signature of S.O. Steshenko is attested.

Acting Scientific Secretary,

O.Ya. Usikov Institute for Radiophysics and Electronics NASU,

Candidate of Sciences in Physics and Mathematics

Olena KRYVENKO

