INFORMATION ON DOCTORAL THESIS

1. Full name: **Do Chi Nghia**
2. Sex: Male
3. Date of birth: 29/10/1976
4. Place of birth: Ha Tay *(now is Ha Noi)*
5. Admission decision number: 1061/QĐ-ĐHSPHN2 November 16th 2014 of Hanoi Pedagogical University 2
6. Changes in academic process: adjusting the dissertation's name and extending the time to carry out the dissertation
7. Official thesis title: **Theoretical models and simulations of plasmonic nanostructures for photothermal and biosensing applications**
8. Major: Theoretical and Mathematical physics
9. Code: 9 44 01 03
10. Supervisors: Scientific Supervisor 1: Dr. Do Thi Nga
    Scientific Supervisor 2: Assoc. Prof. Dr. Chu Viet Ha
11. Summary of the new findings of the thesis:

The thesis studies plasmonic properties and photothermal effects of core-shell nanostructures of different shapes and composite nanostructures based on graphene. From the absorption spectra obtained by the Mie theory, we have developed methods for calculating the temperature rise of nanostructures under laser illumination. New academical contributions of the thesis can be summarized as follows:

- Developing the Mie theory studying plasmonic properties (absorption, scattering and extinction spectra) for core-shell nanoparticles. This complete Mie theory can be accurately calculated to a system of 160 nm when it is compared to experimental data.
- Exploring the optical properties and the thermal-induced stress in the surroundings of heated Ag@Fe_3O_4 nanoflowers in different media using the Mie theory and continuum mechanics theory. Using laser irradiation leads to temperature rise that generates the strain field inside nanoflowers and their ambient surrounding environment. The thermal stress variation has been

analytically found. The long-range stress decays as the inverse of the distance and this finding is in a good agreement with previous study. The stress components in silica decay almost as the inverse cube of the distance near the outer surface. As a result, laser-induced thermoelastic effects can be exploited to detect defects in substances and devices.

- Theoretically study the plasmonic properties of graphene on bulk substrates and graphene-coated nanoparticles. The surface plasmons of such systems are strongly dependent on bandgap and Fermi level of graphene that can be tunable by applying external fields or doping. An increase of bandgap prohibits the surface plasmon resonance for GHz and THz frequency regime. While increasing the Fermi level enhances the absorption of the graphene-based nanostructures in these regions of wifi-waves. Some mechanisms for electric-wifi-signal energy conversion devices are proposed. Our results have a good agreement with experimental studies and can pave the way for designing state-of-the-art electric graphene-integrated nanodevices that operate in GHz-THz radiation.
- Investigating the plasmonic heating of graphene-based systems under irradiation of a mid-infrared laser. The nanostructures comprise a square array of multilayer graphene nanodisks deposited on the diamond-like carbon thin film, which is supported by a silicon substrate. While illuminating the systems by the laser light, plasmonic nanodisks absorb more optical energy than the counterparts without graphene and convert to thermal dissipation. This finding indicates that the ohmic loss is much larger than the dielectric loss in the mid-infrared regime. An increase in graphene plasmonic layers enhances the thermal gradients. At fixed number of graphene layers, the temperature increase is linearly proportional to the optical power and decays as the inverse square of the laser spot. Furthermore, a decrease in the heated temperature, as increasing the thermal conductivity of the thin film layer, is also calculated and discussed.

12. Practical applicability, if any:

The thesis proposes the first semi-empirical research direction in Vietnam on the plasmonic properties of nanostructures and its photothermal applications, so that it can be combined with experimental groups to explain the results and propose new applications. This method is quite simple, has been published in prestigious scientific journals and can completely help experimental groups verify data and predict the results of new generation nanostructures.

13. Further research directions, if any:

- Apply researches of plasmonic to biological systems to figure out how spectra vary with parameters of environment, in order to give suggestions to manufacturing material and devices, as well as biosensors.
- Investigate variation of temperature of nanostructure depending on environment by using laser. Exploit and survey the efficient usage of photothermal effect in medical treatments as well as environmental applications.

14. Thesis-related publications:

[1] Anh D. Phan, Nghia C. Do, and Do T. Nga, "Thermal-induced stress of plasmonic magnetic nanocomposites", *Journal of the Physical Society of Japan* **86**, 084401 (2017).

[2] Do T. Nga, Do C. Nghia, Chu V. Ha, "Plasmonic properties of graphene-based nanostructures in terahertz waves", *Journal of Science: Advanced Materials and Devices* **2**, 371-377 (2017).

[3] Anh D. Phan, Do T. Nga, Do C. Nghia, Vu D. Lam, and Katsunori Wakabayashi, "Effects of Mid-infrared Graphene Plasmons on Photothermal Heating", *Physica Status Solidi - Rapid Research Letters* **14**, 1900656 (2020).