Annals of the Academy of Romanian Scientists
Series on Physics and Chemistry
ISSN 2559 – 1061 Volume 5, Number 1/2020

QUANTUM COMPUTING IN GRAPHENE

Daniela DRAGOMAN[1]

Abstract. *Quantum computing, based on different principles than classical computing, has raised high expectations regarding the increase of computational speed in nano-sized quantum systems. Therefore, the search for implementations of quantum logic gates in photons, spin states, atom/ion traps or superconducting materials, for example, is a very active research area. Graphene has demonstrated already the possibility of implementing reversible logic gates, therefore becoming a compelling candidate for quantum computing applications. The paper presents several proposals of quantum logic gates implementation in graphene, which could work at room temperature and require only current measurements as readout procedures; examples of such quantum gates are Hadamard, C-NOT, C-phase and Toffoli gates. Besides these gates, it is shown that quantum algorithms, such as the modified Deutsch-Jozsa algorithm, can be implemented also in graphene.*

Keywords: graphene, quantum computing, logic gates

https://doi.org/10.56082/annalsarsciphyschem.2020.1.165

1. Introduction

The motivation of searching for new computing methods is based on the fact that the impressive technological achievements in present-day computing architectures reach their limits. In particular, in order to cope with the demand of size scaling described by Moore's law, the complexity of integrated circuits must double every 18 months. Therefore, it is not possible to increase the number of transistors per processor chip beyond 2 billion MOSFET transistors without decreasing their gate length up to few tens of nanometers. As a result, MOSFETs with gate lengths of 30 nm are already in mass production, and the target of the International Technology Roadmap for Semiconductors is the fabrication of transistors with gate lengths of 7.4 nm in 2025 [1]. At such dimensions quantum effects cannot be ignored, and the alternative of quantum computation becomes enticing as well as unavoidable. The interest in quantum computers is also motivated by their predicted ability to solve in polynomial time at least some problems that have no polynomial time solution/cannot be solved in a reasonable amount of time by any classical algorithm [2]. For instance, the problem of finding the prime factors of an integer number benefits from a (sub)exponential speed-up if solved by the quantum Shor algorithm, the speed of searching of an item in an unordered list is quadratically increased by the quantum Grover algorithm, whereas simulations of

---

[1]Prof., Faculty of Physics, University of Bucharest, Bucharest, Romania, corresponding member of the Academy of Romanian Scientists (e-mail: daniela@solid.fizica.unibuc.ro).