Fabrication and Mathematical Modeling of SWCNT Scaffold DNA Spiral Nantenna

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ABSTRACT

DNA origami based spiral structure is synthesized to realize a nanoscale spiral antenna for biomedical applications. Single strand DNA (ssDNA) origami structures utilize self-assembly techniques and short ssDNA staples to develop the desired spiral structures. This poster will discuss the methods and protocol to develop DNA origami structure. We further present several approaches to make DNA conductive. We also present a mathematical model to calculate the conductivity of nanoscale antenna.

PREVIOUS WORK

- DNA origami, folding of long single strand DNA with shorter staple strands, was first presented by (Rothemund 2006).
- Several DNA origami shapes have been reported (Deitz 2009).
- CADnano and CanDo are used for modeling the behavior of DNA molecule.

NANO-SCALE ANTENNAE DESIGN

- Spiral Antennas (Figure 1): exhibit frequency independent impedance and radiation pattern
- Triangular Optical Antennas (Figure 1): have sharp corners that can concentrate static charge.
- Real filed intensity at the corners of triangular antenna makes it an ideal candidate for optical antenna applications.
- Conductivity of such a biological antenna can be achieved by using conductive nanoparticles or CNT growth on DNA scaffold.

Fig 1: Spiral and Triangular antenna design in CANDNANO

INTRODUCTION

- DNA nanostructures, combined with nanoparticles, have a potential to revolutionize nano-electronics.
- **DNA** nanostructures has been used as a scaffold for the placement and routing of Carbon nanotubes (CNT) (Eskelinen-2011)

SWCNT Conductivity

- CNT are cylindrical form of Carbon atoms with an extraordinary mechanical, electrical, thermal, optical and chemical properties.
- CNT is rolled up tube of Graphene and thus the best way for analyzing CNT is to analyze Graphene.
- Using Boltzman transport equation and Schrodinger time independent equation and analyzing the structure of Graphene sheet, we can find the conductivity as follow:

$$\sigma_{zz}(\omega) = j\frac{2e^2}{(2\pi\hbar)^2}\iint \frac{\partial f_0}{\partial p_z}\frac{v_z}{(\omega - j\vartheta)}d^2p$$

$$f_0(p) = \left(1 + e^{\frac{E}{k_B T}}\right)^{-1}$$

$$E = -\gamma\sqrt{1 + 4\cos^2\left(\frac{a_0}{2}k_y\right) + 4\cos\left(\frac{\sqrt{3}}{2}a_0 k_x\right)\cos\left(\frac{a_0}{2}k_y\right)}$$

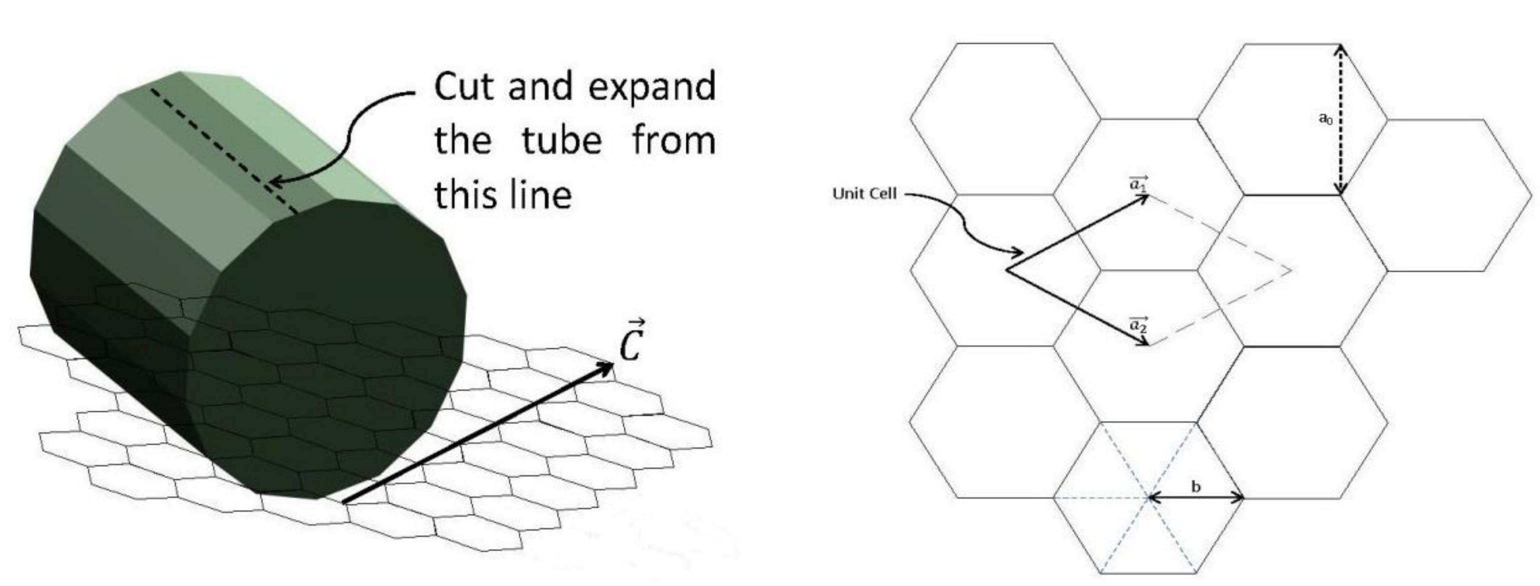
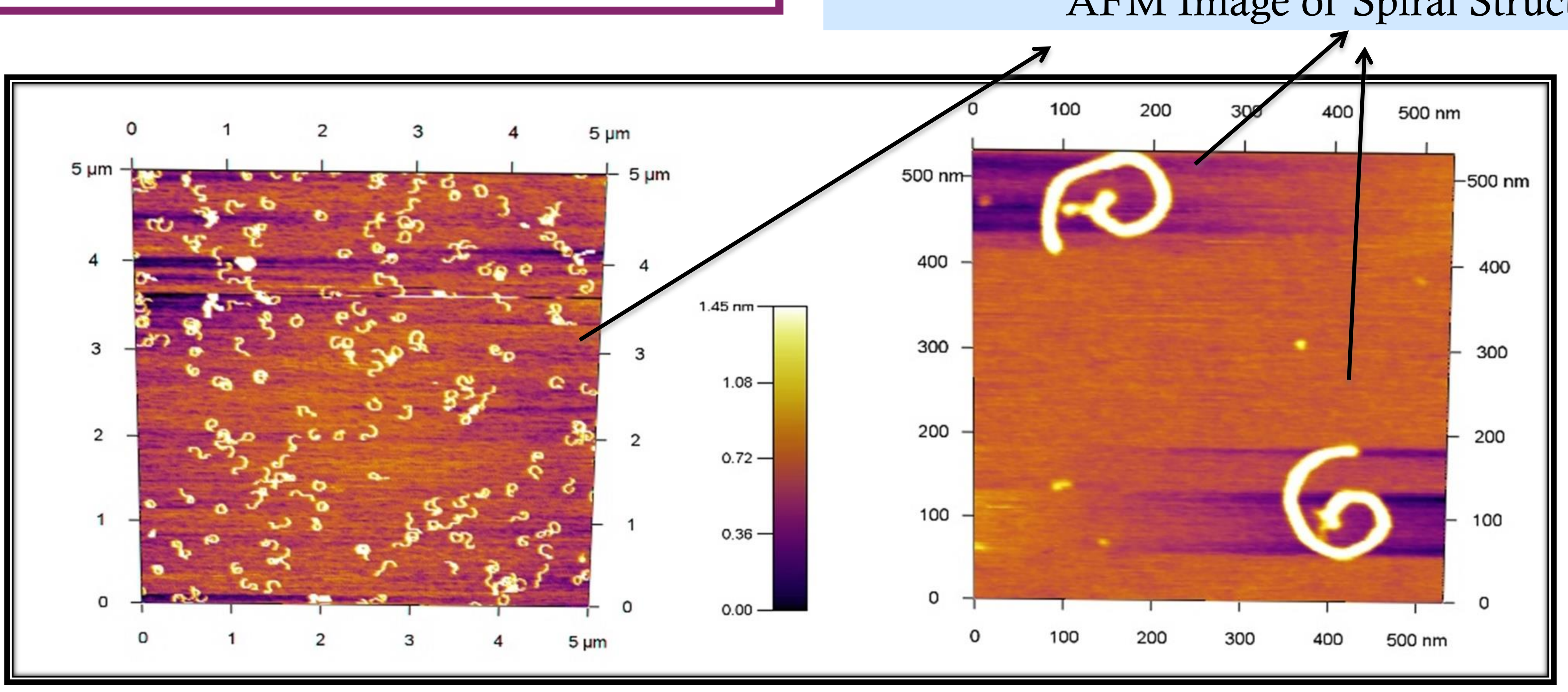


Fig 2. Graphene Unit Cell and $\vec{c}$ vector demonstration

APPLICATION AND CONCLUSION

- The application of such nanostructures are in medicine, power harvesting & nanoelectronics.
- Nano-antennas are carriers that can be used in advanced detection systems and nanotoxicology.

AFM Image of Spiral Structures



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