Investigation of Graphene-Based Coatings for Electroflotation Devices

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We characterize a graphene coating approach to improve the durability of electroflotation devices. Graphene is widely known as a two-dimensional sheet of carbon atoms arranged in a honeycomb crystal lattice with interesting electronic and mechanical properties [1], specifically it is the noblest element on the galvanic series. Recently, the scientific community has made long strides to integrate graphene on electronic sensors and devices [2]. However, it is important to understand how graphene materials can benefit other industries such as in the food and agricultural industries. Due to graphene's high conductivity and impermeability to water and gases [3], graphene is an ideal candidate to replace current anode and cathode materials used in electroflotation. Current materials such as steel and iron are victim to degradation during the electrolysis process and must be replaced often. Carbon materials such as graphite rods have been used consistently in electroflotation devices to increase anode material lifetimes, however, are quite large and fail to produce the necessary bubble sizes needed to accurately filter algae particulates and bacteria such as E. coli [4]. With a methodology for microfabricating graphene and its composits on electrodes, the scientific community can begin to realize the high current densities needed to achieve efficient electrogeneration of tiny bubbles in electroflotation systems.

Highly ordered graphene structures on the order of a few millimeters have been synthesized using laser irradiation of graphene oxide [5]. Aqueous graphene oxide is first dried at room temperature onto a target surface. Than an optical setup consisting of a 785 nm thermo-electrically cooled laser diode with an output power of ~35mW is brought to a small focus to increase the temperature of the graphene oxide surface and allow the reduction of carbon to take place, Figure 1. Laser state and positioning is provided by a control algorithm written in MATLAB and LABVIEW, Figure 2. The MATLAB program converts a user defined image containing the desired electrode configuration and transforms the image into a 2-dimensional array of x and y coordinates consisting of the positions where the focused laser will be turned on and off. The LABVIEW program than passes the positional data to a motion controller and moves a translational stage accordingly. The remaining graphene oxide can be dissolved in water or the graphene structure can be transferred to any target surface using thermal transfer methods.

Figure 3, illustrates a typical electrode configuration used in an electroflotation device and is developed using the laser irradiation method. The structure consists of many graphene sheets stacked on one another with a resistance of ~10Kohm. The additional strength of multiple graphene sheets adds to the durability and almost non-sacrificial properties of the developed material. The large carbon density allows us to realize the potential for high current densities that are necessary to produce a large quantity of tiny bubbles within a small surface area. Finally, we are able to explore complex carbon electrode configurations, Figure 4, in an attempt to reduce the size of electroflotation devices.

References:
[1] A. K. Geim, K. S. Novoselov. "The rise of graphene." *Nature Materials*, *6*(3), 183-191. (2007)
[2] R.C. Ordonez, C. Hayashi, N. Kamin, M.C. de Andrade, D. Garmire, (2014). Charge Amplification of a Graphene-Integrated-CMOS (GIC) RF Detector, *Proc. 2014 TechConnect World Conference: Nanotech*, Washington D.C.
[3] Kim, Hyunwoo, Ahmed A. Abdala, and Christopher W. Macosko. "Graphene/Polymer Nanocomposites," *Macromolecules Perspective* 6515-6530. (2010)
[4] Tumsri, Kan, and Orathai Chavalparit. "Optimizing Electrocoagulation-electroflotation Process for Algae Removal," *IPCBEE* 6: (V2-452)-(V2-456). (2014)

[5] R. Trusovas et al., “Reduction of graphite oxide to graphene with laser irradiation.” *Carbon*, (53)52574-582. (2013)

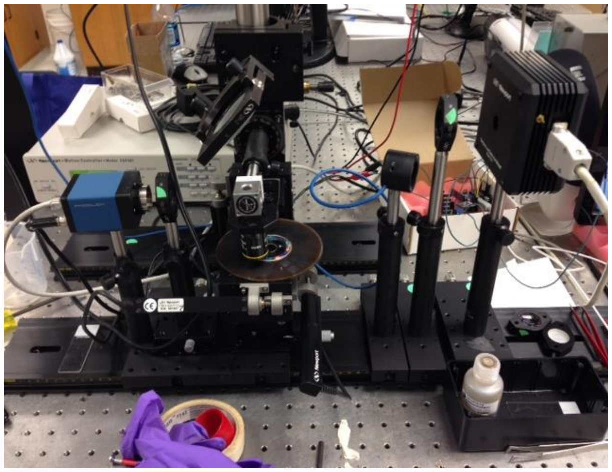

Figure 1: Optical setup utilizing a 785nm TO-Can laser diode

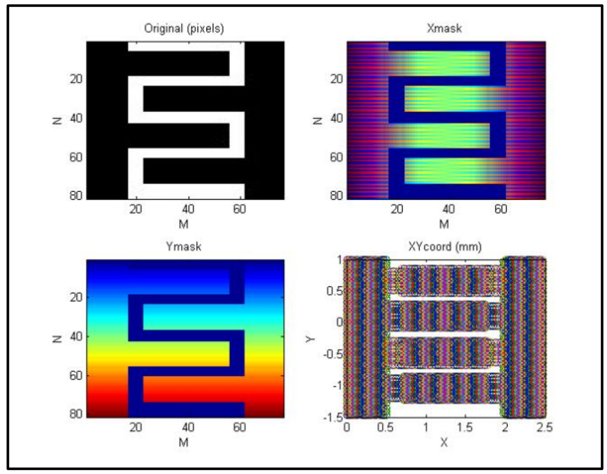

Figure 2: MATLAB Control Algorithm. (Top Left) Original image. (Top Right) X coordinate mask. (Bottom Left) Y coordinate mask. (Bottom Right) XY Positions based on scanning algorithm.

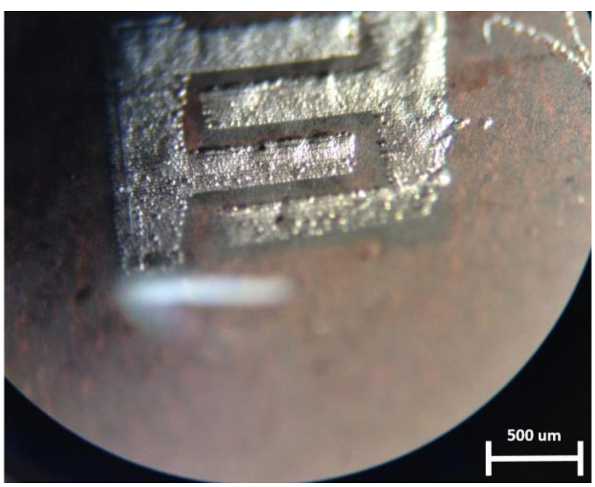

Figure 3: Electroflotation Electrode Design using laser irradiation of graphene oxide

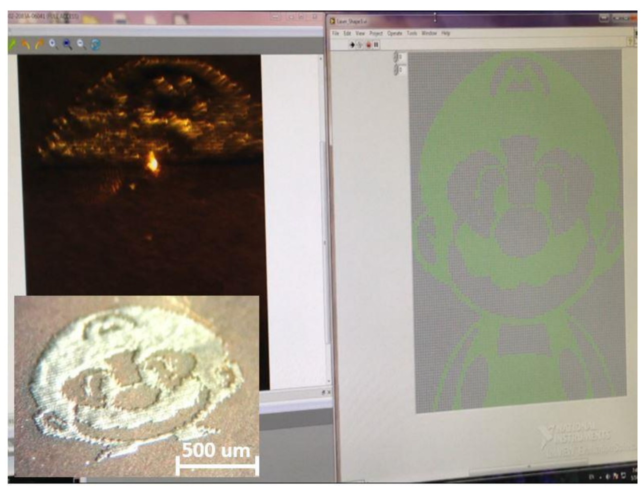

Figure 4: Laser irradiation technique in action of complex carbon structure