# Graphene and Nano-Scale Fiber Bio-Sensing Platform for Early Cancer Detection

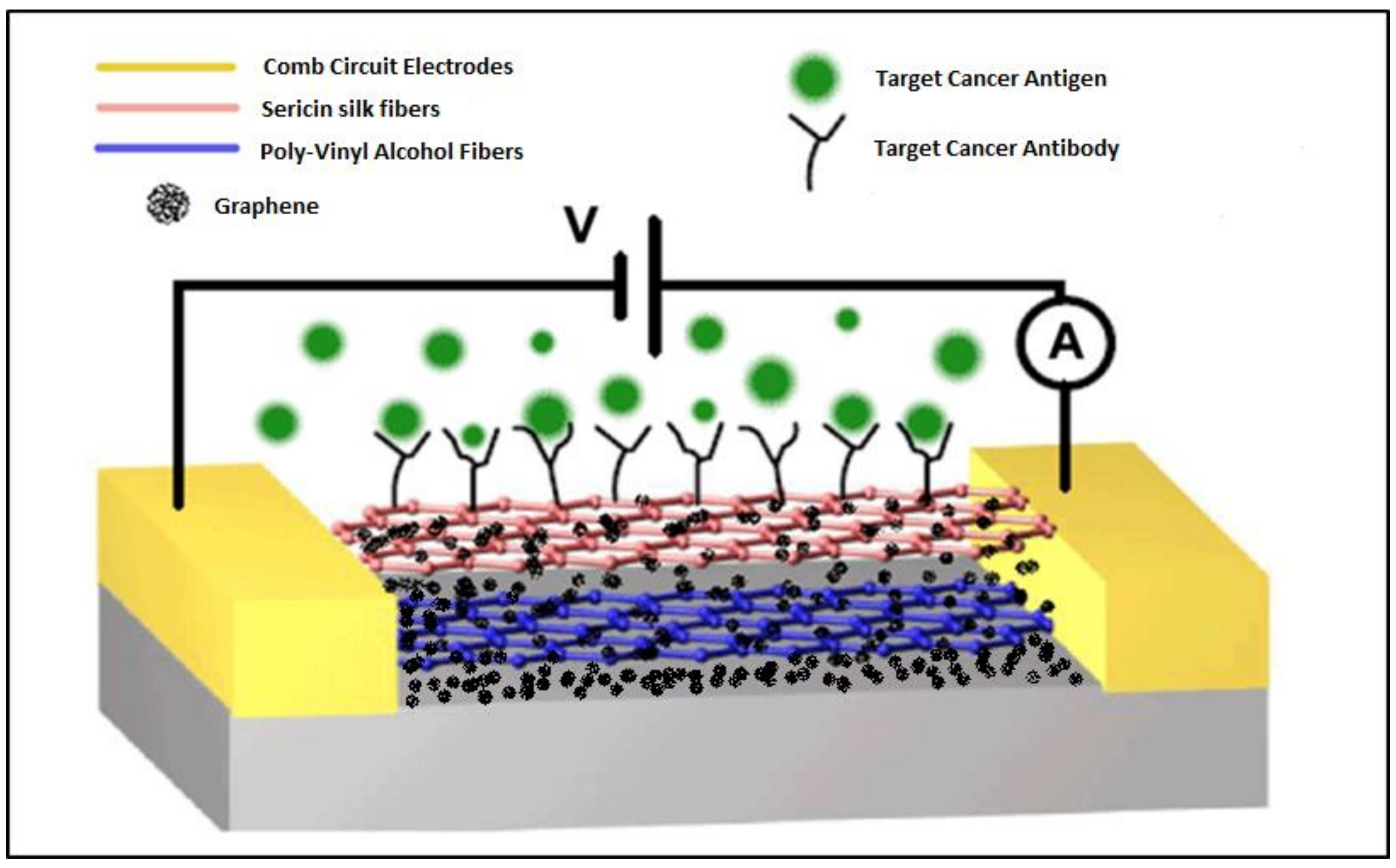
Andrew Martin, Akinwumi Akinkunmi Advisors: Prof. Prabir Patra, Dr. Ashish Aphale
Department of Biomedical Engineering, University of Bridgeport, CT.

## Abstract

On this poster, we present results from our ongoing research toward creating a proto-type of a bio-sensor that can detect cancer antigens in human saliva. A simple comb printed circuit board was designed and manufactured*(Fig 1).* The bare comb circuit is normally open and requires a conductive substance to fill in between the teeth of the comb to complete the circuit. We used graphene as the conductive material. The graphene acted as a soft electrical conductor completing the current path across the comb printed circuit board and created an electrical circuit with a unique current, voltage and resistance. We applied various concentrations of graphene to the comb circuit surface and explored graphene's properties as a soft conductor.

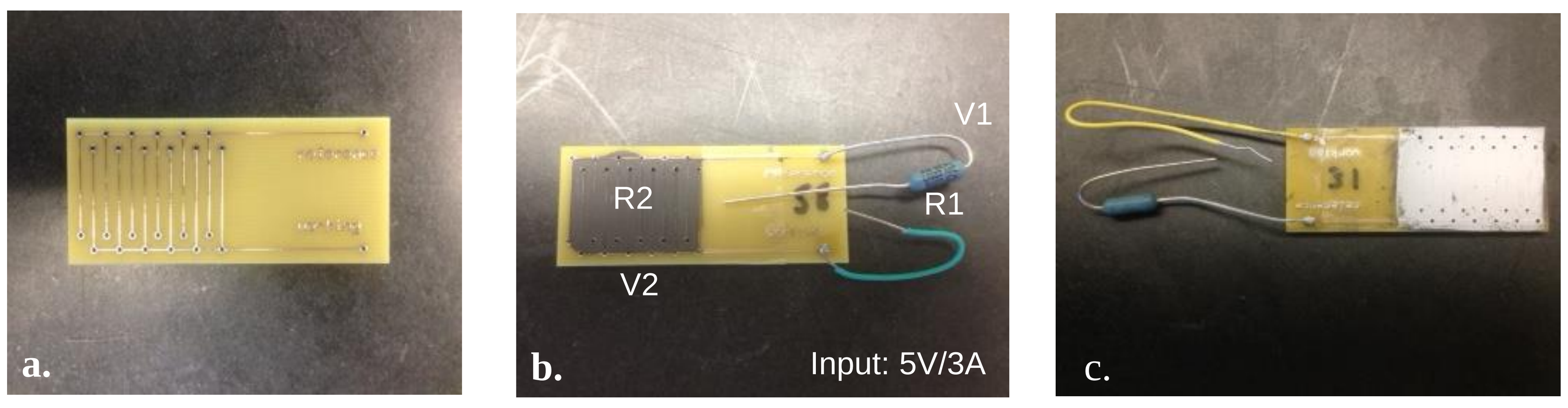
Next, a solution containing Poly-Vinyl Alcohol and Sericin Bombyx mori silk solution was electro-spun onto the circuit board creating a sticky cob-web-like covering over the comb circuit. This fabric acted as a resistor on the comb circuit and creates a sticky surface to which target cancer antibodies can be attached. Once the target cancer antibodies are attached to the circuit surface, a bio-sensing platform will be created to detect cancer antigens in fluid. When exposed to a fluid sample such as saliva that contains the complimentary cancer antigen to the antibody, the antibodies and antigens will spontaneously bind. This bound antibody/antigen structure will change the impedance of the electrical circuit. This change in impedance can then be detected, quantified and correlated to antigen concentrations in the saliva sample. Further research can then be done to correlate the impedance readings to dangerous cancer antigen concentrations in the human body.

## The Concept



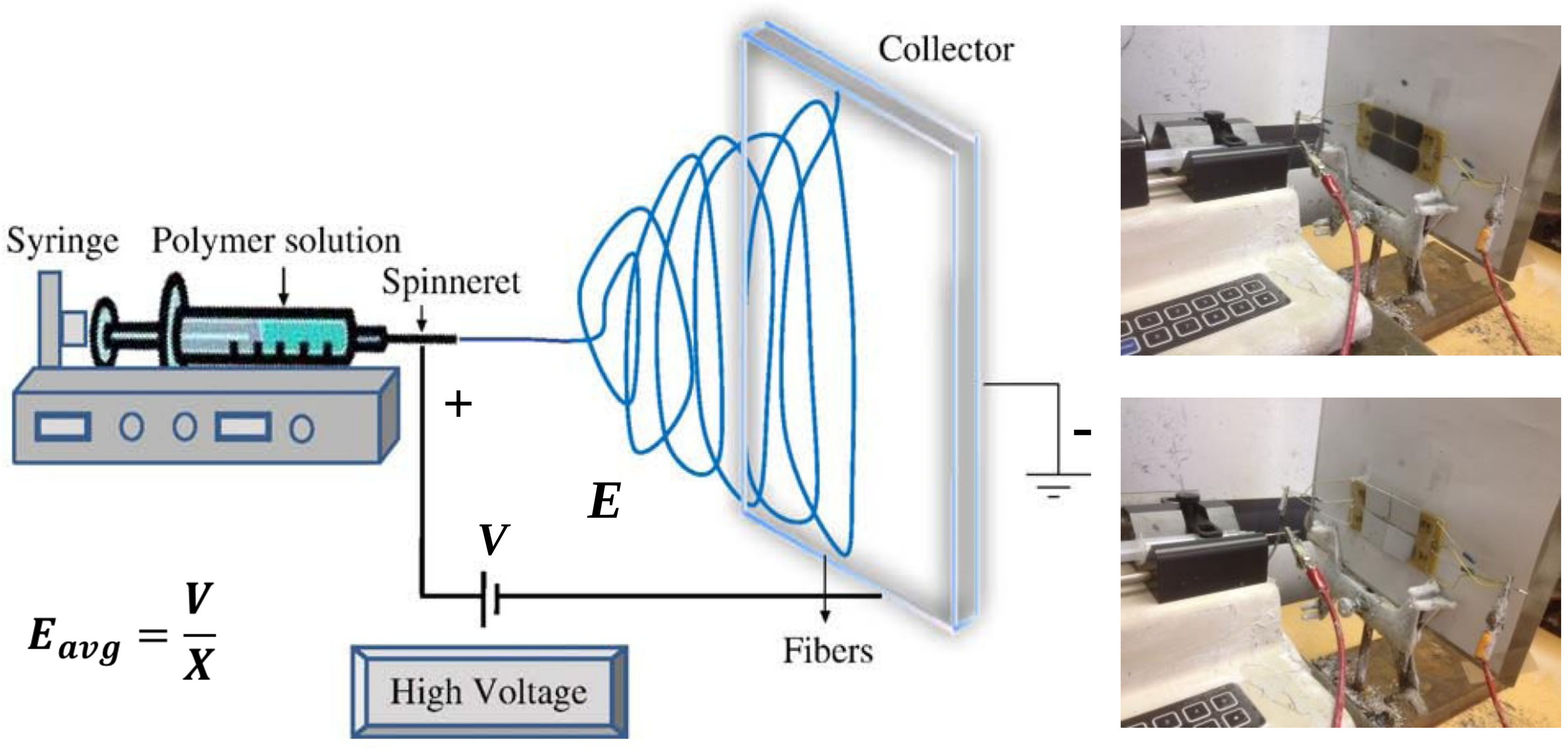

*Conductive graphene allows current to flow between comb circuit electrodes. Electro-spun poly-vinyl alcohol and Sericin silk create sticky foundation for attachment of target cancer antibodies. Target cancer antigens spontaneously bind with antibodies and change the potential and impedance of the circuit*

## The Comb Circuit




*a.) The bare comb circuit. b.) Conductive graphene applied to the surface creates a current path and creates a circuit with unique current, voltage and resistance. C.) Electro-spun PVA/silk increases resistance and creates a sticky platform for the attachment of antibodies.*

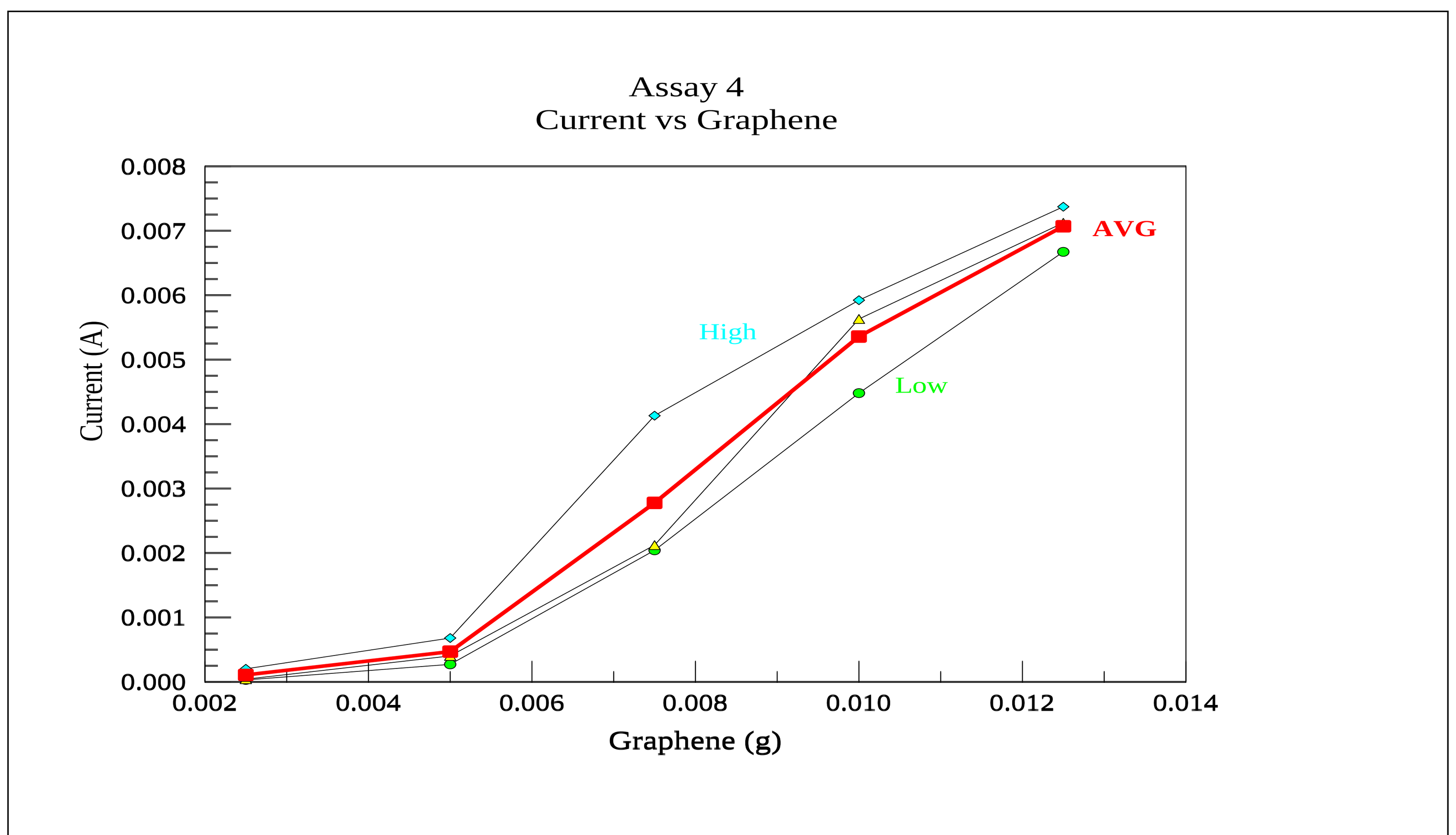
## The Electro-Spinning Process




*The polymer solution is ejected by the fluid controller into the electric field. High voltage generator creates a strong electric field between the syringe tip(+) and the collector(-). The polymer solution is stretched into semi-continuous nano-scale fibers between syringe tip and collector. Electro-spun fabric accumulates at the collector. The strength of the electric field ($E$) is determined by the equation ($E_{avg} = \frac{V}{X}$). Where $V$ is the voltage provided by the generator and $X$ is the distance between syringe tip and collector.*

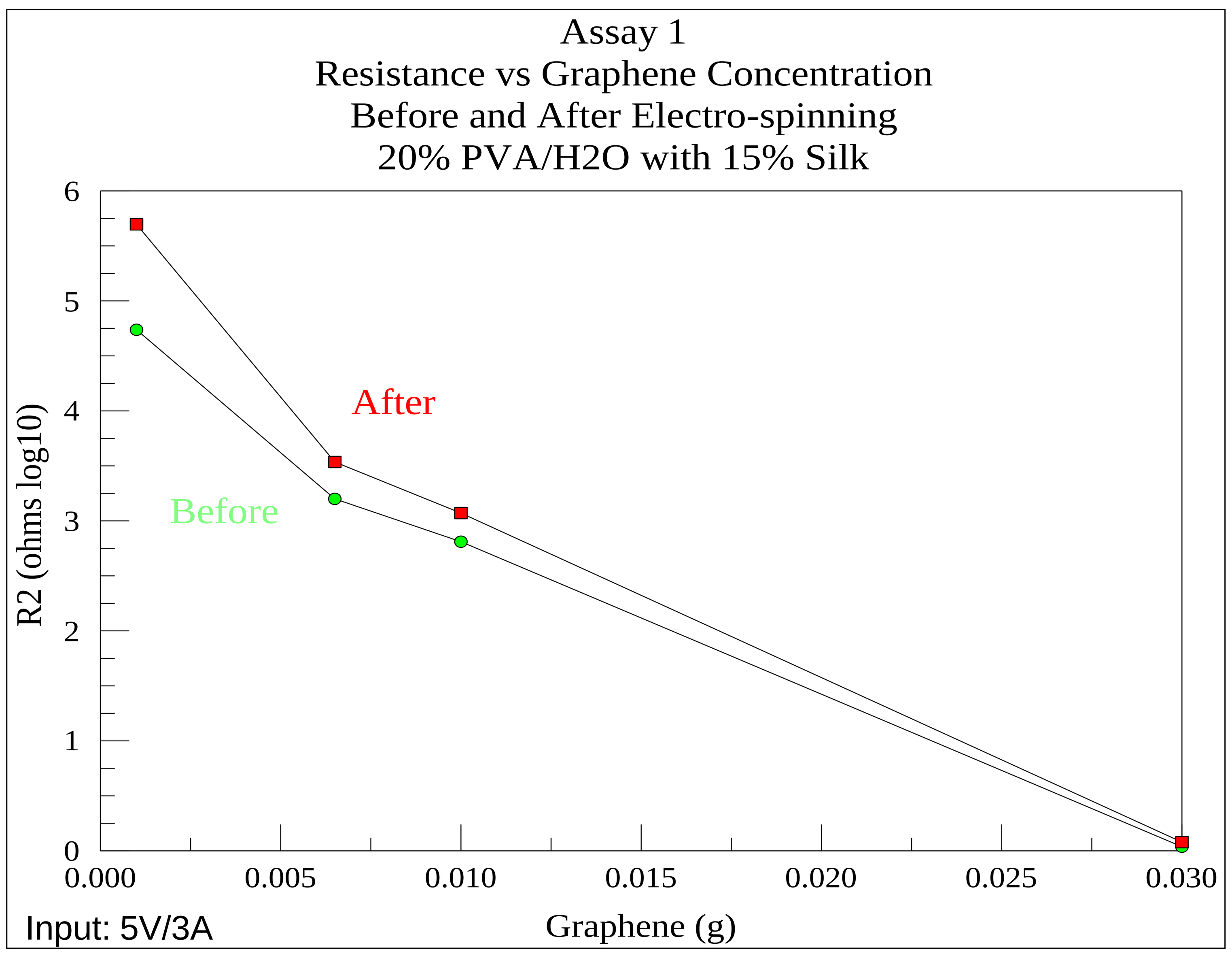
## Results

### Graphene as a soft conductor



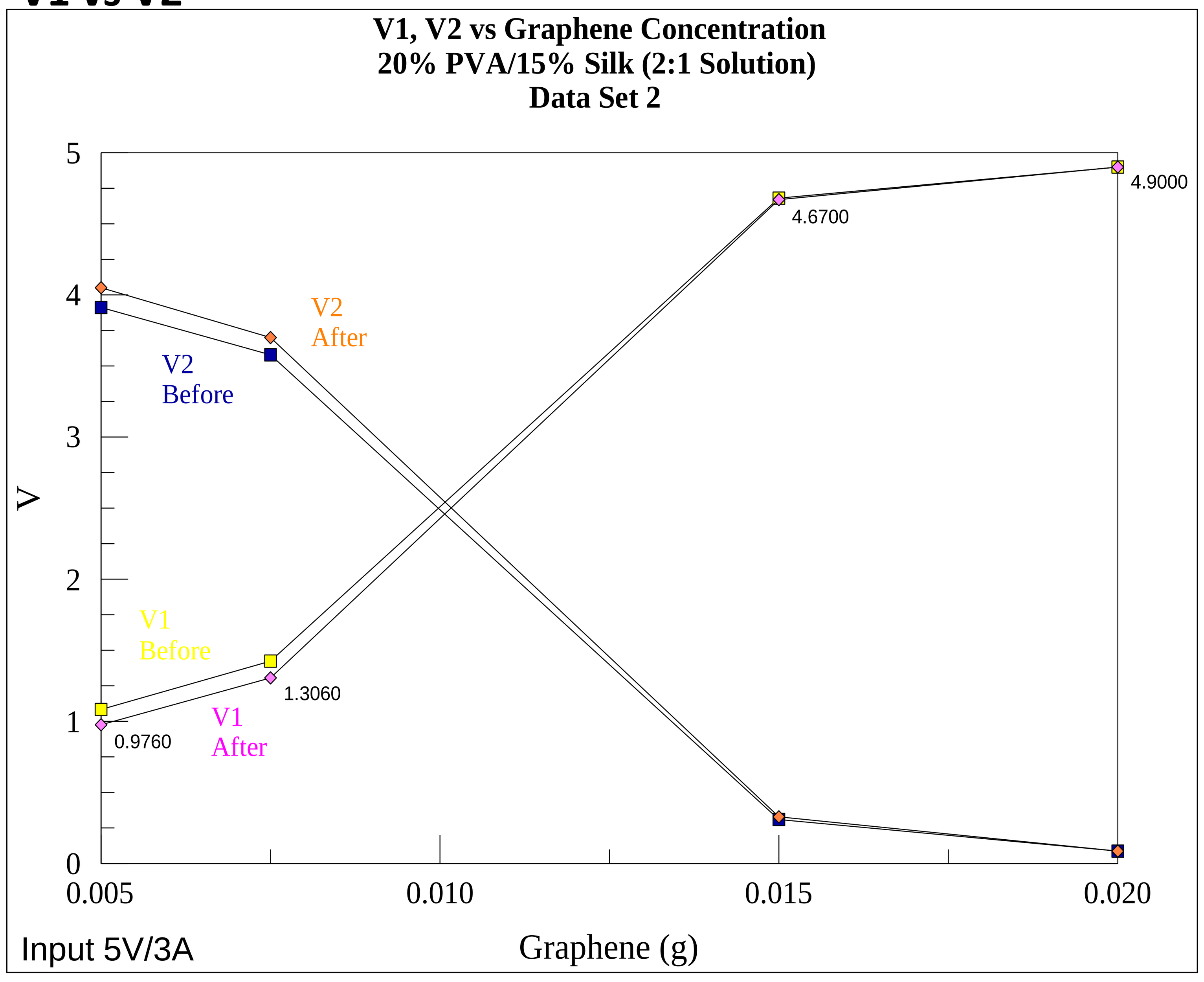

*This graph shows the relationship of conductivity to graphene concentration on the comb circuit for Assay 4 which consisted of 15 printed circuit boards. 5 different graphene concentrations were used with 3 circuit boards per concentration. It is clear that conductivity rises as graphene concentration increases on the circuit surface. The green line indicates low range, the yellow mid-range and the blue high range. The red line is an average of the three.*

### Electro-spun PVA/Silk as a resistor




*The green line represents resistance across the comb circuit before electro-spinning, the red line after electro-spinning. It is clear that resistance across the comb circuit drops as graphene concentration on the circuit surface increases providing additional evidence of graphene as a soft conductor. Also, it shows that resistance increases after electro-spinning fibers onto the comb circuit providing evidence that the fibers act as a resistor.*

### V1 vs V2




*This graph shows voltage vs graphene concentration data for Set 2 which contained 4 circuit boards. V1 is the potential across the resistor (see picture b. at left). V2 represents the potential across the comb circuit. As V2 drops with increased graphene on the circuit surface, V1 increases according to Ohm's Law and Kirchoff's Voltage Law. It also shows voltage increasing across V1 and V2 after electro-spinning which is expected since resistance increases with addition of fibers on the circuit surface.*