Textile Based Carbon Nanostructured Flexible Antenna

Prabir K. Patra, leader; Paul D.Calvert, Steven B.Warner, Dayalan Kasilingam (Umass Dartmouth), Pulickel M.Ajayan (RPI) and Branislav Notaros (Colorado State University)

Our research aims at patterning of carbon nano tube-conducting polymer based electronic ink on a textile substrate by controlled micro-droplet deposition and its diffusion into the fabrics to design flexible antennas and antenna arrays in the microwave and millimeter wave frequency ranges. This study also stresses the need to find a highly conducting nanotube based alternative to silver for RFIDs. We are developing appropriate nanotube -polymer conductive ink formulations. Printing several patterns on the fabrics and plastic films has been carried out. We have carried out useful electrical measurements such as gain vs. conductivity and impedance matching to establish the antenna principles in the materials.

CNT-conductive polymer electronic inks

We have inkjet printed CNT conducting polymer electronic ink on a flexible textile substrate. In order to have sufficient flexibility, weight and conformity, we have used carbon nanostructured conductor inks and conducting polymer inks instead of metallic conductors. Several ink formulations included PEDOT, aqueous CNT dispersions and CNT-conducting polymer based inks. We investigated the effect of various additives to create stable dispersions of carbon nanotubes in an aqueous medium. Our ink formulations also included commonly cited additives in literature such as gum arabic, sodium dodecyl benzene sulfonate (SDBS) as well as polymeric additives such as poly-styrene sulfonate (PSS), poly-styrene sulfonate grafted with maleic anhydride (PSS-MA) and poly-vinyl pyrrolidone (PVP) were investigated [1-6]. We were able to form ordered arrays of nanotubes conductive polymer lines when deposited onto glass slides and papers as shown in figure 1(a) thus providing feasibility of printing such structures on to textile substrates. Junction resistance of carbon nanotubes plays a pivotal role in increasing the overall resistivity of networks. To further enhance conductivity, we investigated the process of preparation of multicomponent dispersions, including metal nanoparticles so as to improve overall conductivity of printed designs. The overall goal for this process would be to have the presence of metal nanoparticles at nanotube-nanotube junctions so as to reduce junction resistance as shown in figure 1(b).

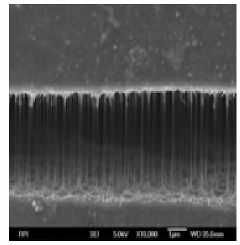


Figure 1(a): SEM image of SWNT-PVP ink dried onto glass

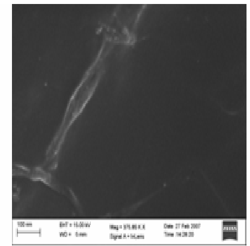
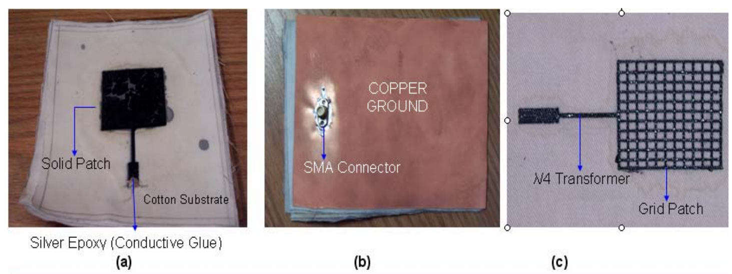


Figure 1(b): CNT-CNT junction with presence of gold nanoparticles at the interface

Inkjet printed microstrip patch antenna:

Based on the modeling results, we have built a prototype of a polymer-based wearable microstrip antenna. The antenna's radiation pattern and impedance are measured in an anechoic chamber.



a) Top view b) Bottom view of the prototype c) Grid patch design

The antenna of solid patch is ready for measurements. Silver epoxy was used to connect the feeding node to the antenna.

Figure2: Antenna patterns using SWNT-conductive polymer inks

With the introduction of personal communications technology, wearable antennas have recently received growing interest. Principal requirements for a wearable textile antenna:

- Low profile and small size
- Ability to minimize the radiation absorption by the human body,
- Guaranteed operation even when covered by wet clothing or mud
- Reasonable gain

Microstrip antennas appear to be more suitable for wearable applications. We have been trying to solve the problem of having a wearable microstrip antenna with a lossy conductor. Our theoretical solutions so far have showed us:

Conductivity has a deterministic role on antenna parameters.

- Theoretically, the PEDOT/PSSS and CNT based electronic ink has enough threshold conductivity and they can be used as the conductor for a patch antenna.
- As long as the ground has sufficient dimensions, the radiation absorbed by the human body won't reach critical limits and human antenna interaction won't play a significant role on the antenna performance. .
- In order to provide sufficient durability, conductor inks have to be developed.

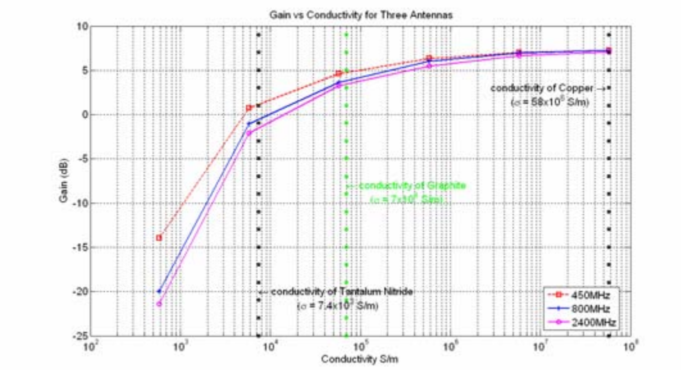


Figure 3: Gain vs. Frequency for three antennas of 450MHz, 800MHzm 2.4 GHz resonant frequencies

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Other Contributors:

Graduate Students: Arpit Laddha and Erdem Yelmiz (UMD), Sandeep Razdan and Trevor J. Simmons (RPI)

Industry Interactions: We have established strong contacts with ICI for this research through our ongoing effort a . We will work closely with Paul Nahass, Foster Miller Inc, in this research. Foster Miller Inc is one of the leading players in the electronic textile area and Paul Nahass has regular interaction with UMass Dartmouth through one of the PIs (PDC). Ajayan has very strong research relations with IBM and Intel and we will establish stronger working relations with them as we proceed in our research. Project leader (PKP) has established contacts with Glynda Benham, Megawave corporation, an antenna research and development company in Boylston, MA. Notaros has strong working relation with Dr.Miroslav Djordjevic of Antenna Research Associates (ARA), Inc, a leading antenna manufacturing house, Beltsville, MD has shown tremendous interest in this research.

Project Web Addresses:

http://www.ntcresearch.org/projectapp/?project=M06-MD01