# Highly Tunable, Ultrastretchable Liquid Metal Wire Antennas

Clifford Muchler*[1], Ying Liu[2], Michael D. Dickey[2], and Jacob J. Adams[1]

[1] Department of Electrical and Computer Engineering, North Carolina State University, Raleigh, NC, 27695

[2] Department of Chemical and Biomolecular Engineering, North Carolina State University, Raleigh, NC, 27695

Stretchable antennas developed using new material systems may play an important role as wearable sensors or mechanically tuned elements. Antennas have been integrated into stretchable substrates by a variety of methods. For example, conductive inks or thin foils printed onto fabrics and metal nanowires embedded within an elastomeric matrix have been demonstrated in recent years. Though the aforementioned systems have many applications, mechanical limitations of both the dielectric and conductors make them ill suited for applications requiring metallic conductivity at very high strain (over 100%). For instance, conductive thin films are conformable but tend to fracture under moderate strain. Antennas realized utilizing nanowires/nanoparticles embedded in an elastomeric substrate are more stretchable than their thin film counterparts, however conductivity drops significantly with strain due to the solid, discrete nature of the conductive particles.

For tunable antennas, the direct relationship between antenna dimensions and operating frequency indicate that the ability to maintain conductivity at high levels of strain is the key to wideband mechanical tunability. In this work we demonstrate highly tunable reversibly deformable wire antennas for VHF/UHF communications, utilizing a new type of flexible conductor. The conductors consist of hollow ultra-stretchable elastomeric fibers made from poly[styrene-b-(ethylene-co-butylene)-b-styrene] (SEBS) with a liquid metal core composed of eutectic gallium indium (EGaIn, 75% Ga, 25% In by weight). The fibers are connectorized with standard, sub-miniature type-A connectors (SMA) and are interfaced with a 3-port balun to realize dipole and loop configurations. The novelty of this work lies in the high conductivity and durability that is achieved under strain without degrading the antennas' mechanical or electrical properties. The liquid metal/fiber material system enables highly conductive wires that can be stretched to up to 10 times their native state without a dramatic decrease in their conductivity. In this work we will present dipole and loop antennas that can be tuned over multiple octaves. Anechoic chamber measurements will show that the liquid metal antennas are comparable to conventional wire antennas with respect to radiation efficiency, gain and pattern. Lastly it will be shown that the dipole and loop antennas can be easily adapted into more directive geometries.