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Paper-based Electronics for Sanitization and Skin-like Functionality

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As a material, cellulose/paper has attracted significant attention for its fibrous, renewable, and bendable properties. Paper is a renewable resource with the most common forms coming from trees. Consisting primarily of polymeric cellulose, paper is a multi-scale material with millimeter-scale structures built on interlocking micro and nano fibers. This fibrous network permits wicking/handling of liquids for electro-chemo-mechanical sensors and devices. Paper also has tunable stress-strain relationships, which can be soft with similar mechanical impedance to biological tissue or hard with a theoretical elastic modulus for cellulose nanocrystals greater than steel and similar to Kevlar. Cellulosic fibers are also compatible with metallization, conductive coatings, nanotubes, and graphene for patterned electrical properties.

This talk will initially describe "electronics on paper," which include examples of touch sensors and plasma-based sanitizers. The skin-like touch sensors use patterned resistive networks for passive, scalable sensing with a reduced number of interconnects. When touched or wetted with water, the sensors in the resistive networks detect significant changes in electrical impedance. The plasma generators with layered and patterned sheets of paper provide a simple and flexible format for dielectric barrier discharge to create atmospheric plasma without an applied vacuum. When electrically driven with oscillating peak-to-peak potentials of ±1 to ±10 kV, the paper-based devices produced plasmas capable of killing greater than 99% of *Saccharomyces cerevisiae* (yeast) and greater than 99% of *Escherichia coli* cells with 30 s of noncontact treatment. To move toward functionalized substrates, the final portion of the talk will illustrate our efforts to form fibrous sheets with tunable electrical properties to create "electronics in paper." These materials produced with modified techniques in a hand sheet former represent our efforts to leverage papermaking techniques to tune the electrical conductivity and piezoresistivity of papertronic devices.

Biography
Aaron Mazzeo is an assistant professor in the Department of Mechanical and Aerospace Engineering and a faculty fellow at the Honors College at Rutgers University. Prior to joining the faculty at Rutgers, he was a postdoctoral fellow at Harvard University in the Department of Chemistry and Chemical Biology, and he completed his undergraduate (S.B.) and graduate degrees (S.M. and Ph.D.) at MIT in the Department of Mechanical Engineering. The Mazzeo Research Group focuses on flexible and disposable electronics for mechanical and biological sensing, soft robotics, additive manufacturing, and wireless structural health monitoring. Funding has come through Rutgers University, the National Science Foundation, and NASA. Aaron has received an NSF CAREER Award, NASA MSFC Summer Faculty Fellowships, an A. Walter Tyson Assistant Professorship Award through the School of Engineering, and a Rutgers Engineering Governing Council's Professor-of-the-Year Award. He and his family have also appreciated living and participating as members of the Rutgers Honors College community.

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