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Molecularly Stretchable Electronics for Energy and Healthcare.

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The term "plastic electronics" masks the wide range of mechanical behavior possessed by films of π-conjugated (semiconducting) small molecules and polymers. Such materials are promising for biosensors, large-area displays, low-energy lighting, and low-cost photovoltaic modules. There is also an apparent trade-off between electronic performance and mechanical compliance in films of some of the best-performing semiconducting polymers, which fracture at tensile strains not significantly greater than those at which conventional inorganic semiconductors fail. The design of intrinsically deformable electronic materials—i.e., imagine a semiconducting rubber band—would facilitate roll-to-roll production, mechanical robustness for potable applications, and conformal bonding to curved surfaces. This seminar describes my group's efforts to understand and control the structural parameters that influence the mechanical properties of π-conjugated polymers. The techniques we employ include synthetic chemistry, spectroscopy and microstructural characterization, computation from the molecular to continuum level, and electrical measurements of devices. A complex picture emerges for the interplay between molecular structure, the way the process of solidification influences the morphology, and how molecular structure and morphology combine to produce a film with a given modulus, elastic range, ductility, and toughness. We are also exploring ways to introduce other properties into organic semiconductors that are inspired by biological tissue. That is, not just elasticity and toughness, but also biodegradability and the capacity for self-repair. The seminar will also touch on our use of self-assembled metallic nanoislands on graphene for ultra-sensitive mechanical sensing using piezoresistive and "piezoplasmonic" mechanisms. The applications for these materials are in detecting human motion and measuring the mechanics of cardiac and musculoskeletal cells. My group is broadly interested in the intersection of soft materials and human touch for virtual and augmented reality, and I will briefly mention our work in these areas.