# Integrating Energy Storage and Piezoelectric Devices for Flexible and Planar Energy Harvesting

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Harvesting mechanical energy is the next step in energy recycling for a green energy economy, able to be applied across large scale power generation from the motion of water, wind, and vehicles through to human motion powered wearable electronics (Shepelin 2019, a). Piezoelectric polymers have emerged as attractive candidates for these human motion powered systems as they are processable, flexible, transparent, and light weight (Shepelin *et al*. 2019, a,b) While continuous power generation is possible for large scale energy harvesting systems, the harvested energy needs to be stored for use 'on-demand' for human motion based devices. Building a flexible integrated device incorporating both an energy harvester and energy storage unit is crucial to satisfying the weight and areal footprint requirements for wearable electronics. Supercapacitors, with their fast charging rate and potential driven charging mechanism, have emerged as leading candidates for the energy storage components of integrated energy harvesting. However, there are still limitations stymying their efficacy. Specifically, the discrepancy between timescale of piezoelectric power generation and charging of supercapacitors, and the potential for discharge from the supercapacitor back into the piezopolymer.

Here we show a pathway to overcome these limitations in coupling piezoelectric fluoropolymers, specifically the 3D printed PVDF-TrFE, with a hybrid reduced graphene oxide supercapacitor. Our approach has been three-fold (as shown in Figure 1); Use of laser scribe graphene to precisely engineer electrode architectures (Kurra *et al.* 2019); incorporation of an inkjet printed p-n diode from the 2D materials $WS_2$/$MoS_2$, providing an excellent interface with both PVDF-TrFE and graphene by capillary and van der Waals forces respectively; and use of a redox active gel, KI and $VOSO_4$, coupled with conventional PVA/H2SO$_4$ electrolytes, enabling faradaic charge storage independent of a maintained voltage. The combination of these techniques allows us to capture and store energy harvested from human motion, with the supercapacitor holding charge over multiple days without motion.

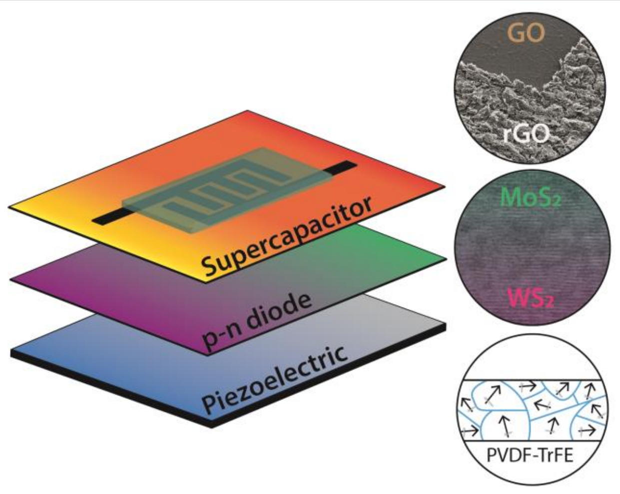


**Figure 1**. Exploded schematic of the flexible energy harvester; insets show the microstructure of electronic device

## References

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