25. Solar energy harvesting fabric for wearable, mobile, and off-grid applications

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Wearable and mobile electronic devices play a dominant role in our modern lives, however robust and sustainable energy solutions for powering them is still an unmet need. Textile fabrics are large area structures that can be worn by a user, hence are a suitable platform for a wearable/mobile solar energy solution. In this work a novel solar energy harvesting fabric is presented. The fabric is constructed by weaving miniature solar cell embedded textile yarns (solar yarns) fabricated using the E-Yarn technology [1]. The fabric has textile like haptic (soft, conformable and breathable) and aesthetic properties and is also machine washable and mechanically robust making it superior to other textile energy solutions reported in literature [2], [3] for wearable and reusable applications. The fabric can be rolled and is lightweight, making it desirable for mobile and off-the-grid energy needs.

The solar energy harvesting fabric demonstrated here was woven using 20 solar cell embedded textile yarns creating a solar cell footprint of 50 mm × 45 mm. The solar yarns were fabricated by soldering ten miniature crystalline silicon solar cells (3 mm × 1.5 mm), in parallel, onto two fine multi-strand copper wires before encapsulating them individually inside of clear resin micro-pods. The encapsulated cell strand was then covered by a textile fibrous sheath comprising packing fibres and a tubular knitted structure. The resultant fabric generated a short-circuit current, an open circuit voltage, and a maximum power output of ~14.5 mA, ~5.1 V and 45 mW respectively, with a ~2mW/cm^2 power density under one sun (1000 W/m^2) solar illumination. The solar energy harvesting fabric can fully charge a 110 mF (3.2V) textile-form super capacitor bank within one minute and is suitable for charging a smart watch or a basic mobile phone. Additionally, by impregnating the photoactive side of solar yarns with a clear polymer resin, a ~60% increase in power output can be realized.

The solar yarns (in fabric form) survived a minimum of 15 machine wash and line dry cycles and 6000 abrasion cycles without deterioration in performance, confirming their utility for washable and reusable products.

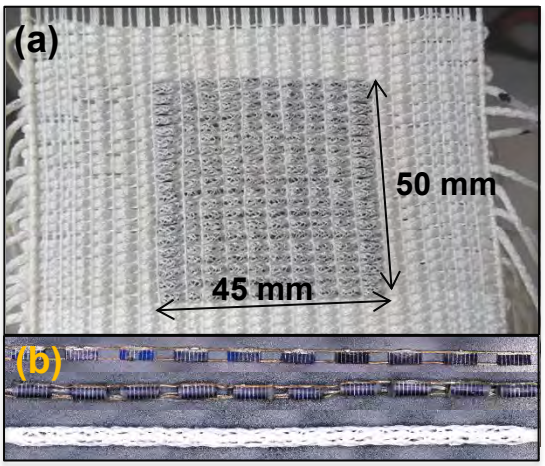

Figure 1 *– (**a**) Image of the solar cell embedded fabric. (**b**) Images of solar cell yarns after soldering (**top**), after encapsulation (**middle**) and after covering with fibrous sheath (**bottom**)*

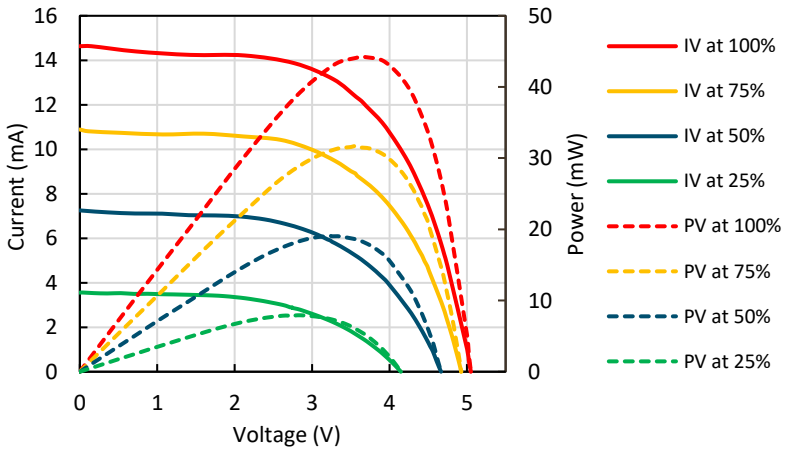

Figure 2 *– Characteristic curves (current/voltage-IV) and power/voltage -PV) for the solar cell embedded fabric under different irradiance intensities (one sun=100%).*

References

[1] T. K. Dias and A. Rathnayake, “Electronically functional yarns,” GB259900B, 2017.
[2] T. Hughes-Riley, T. Dias, and C. Cork, “A Historical Review of the Development of Electronic Textiles,” *Fibers*, vol. 6, no. 2, p. 34, May 2018.
[3] F. C. Krebs and M. Hösel, “The Solar Textile Challenge: How It Will Not Work and Where It Might,” *ChemSusChem*, vol. 8, no. 6, pp. 966–969, 2015.