Hybrid photovoltaic-piezoelectric film/fibre

Harvesting energy from sun, wind, rain and tide

At a glance

Renewable energy sources such as sunlight, wind and rain are not all available all the time at any given location. Photovoltaic energy can be expensive if the solar radiation in a particular region is not abundant. But where solar radiation is scarce, that region may offer alternative harvestable energy sources from high winds and rainfall.

By coupling flexible solar cells with flexible piezoelectric material in a combined hybrid structure – such as tent windows - energy from all the natural resources such as solar radiation, winds, tides and rainfall can be harvested. With a range of surface, underwater and space applications, this capability also has exciting implications to achieve a range of “self charging” devices – most obviously including cellphones, and laptops.

The University of Bolton’s Institute of Materials Research and Innovation (IMRI) has expertise in functional materials such as piezoelectric and photovoltaic materials. And for the first time (late 2010) a hybrid photovoltaic-piezoelectric device has been developed at the centre in the form of films and fibres.

Challenges

Current commercial photovoltaic cells are either mechanically rigid and fragile or expensive. Making them flexible increases the number of applications for harvesting energy - such as photovoltaic cells embedded in tents, window curtains etc. Crucially, the flexibility of the cell also markedly increases durability over existing photovoltaic cell technology.

A novel technology has been developed that integrates piezoelectric polymer substrate with a photovoltaic coating system. This creates a film or fibre structure that is capable of harvesting energy from nature - including sun, rain, wind, wave and tide.

The raw materials used are inexpensive starting with the piezoelectric material which is extruded and poled. And since the organic photovoltaic material system is made in a normal atmospheric environment, the cost associated with the whole structure is markedly lower than a ceramic-based photovoltaic. The resultant material system is flexible and can be incorporated in textiles for a wide variety of applications.

Approach

A continuous process of producing piezoelectric polymer fibre has been developed for the first time and was tested for its voltage generation.

An organic photovoltaic cell based on P3HT and PCBM has been developed on a piezoelectric PVDF polymer substrate. The hybrid films are developed by depositing the organic photovoltaic cell on a commercial PVDF film whilst the hybrid fibres are developed by depositing organic solar cell on the piezoelectric polymer fibre.

Solution

The hybrid piezoelectric-photovoltaic cells have been produced and tested under solar simulator and the open circuit voltage and short circuit current produced has been measured.

The hybrid piezoelectric-photovoltaic cell was also tested in a wind tunnel at various wind speeds and voltage produced was measured. The hybrid cell was also tested under a rain drop simulator set-up for different rain drop sizes falling from different heights and voltage produced by the hybrid cell was measured.

Benefits

A hybrid photovoltaic-piezoelectric thin film and fibre based device was developed for the first time that generates electric energy from solar, rain, tide and wind energy hence, increase the total amount of energy produced by this device at a given place.

The hybrid photovoltaic-piezoelectric thin film and fibre are produced from less expensive raw materials - making them cheaper than the traditional photovoltaic devices. The new “smart” fabric developed at IMRI can and bring together renewable energy technologies for a wide variety of applications on land, underwater and space. It can also revolutionise the textile industry.

Discussions to develop the technology for specific applications are progressing with several potential industry partners.