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Machine Learning Approach for TiO_2 Electrode in Supercapacitor Fabrication

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Extended Abstract

Recent researches have been shown in reliable energy storage, we need both appropriate energy and power density at the same time. This can be achieved by using hybrid storage systems. Due to the different electrochemical behaviour of storage devices in hybrid systems, the main goal is to provide sufficient power and energy upon system request [1]. As a high technological tool, the laser can help us to manipulate the physical and chemical properties of potential electrode materials to increase the general efficiency of energy storage systems. Applying the laser pulses for increasing the porosity of the material surface needs us to optimizes the four main fabrication laser parameters (Frequency, Power, Pulse Duration (PD), and Scanning Speed(SS)). Predetermined electrical properties of supercapacitors can be achieved by changing the mentioned fabrication inputs (laser parameters) [2]. We are proposing a machine learning algorithm that can be used to optimize the fabrication parameters to fabricate higher efficiency supercapacitors.

In TiO_2 supercapacitors, as a consequence of highly complex reaction between electrodes and ions, material and cell design has a critical impact on the performance [3]. In this article, we used a logistic regression algorithm to optimize laser parameters. Furthermore, we used 321 supercapacitors' electrical properties to make a logic algorithm to find the best point in electrode fabrication.

Logistic regression is a statistical model that, in its basic form, uses a logistic function to model a binary dependant variable [4], although many more complex extensions exist. In this work, we used up to eight laser variables for two electrodes for our supercapacitor (inputs) and we measured the electrical properties of a generated supercapacitor (outputs) [5].

After 1000 iteration with an initial population of 231, logistic regression is providing an appropriate accuracy of ~80%. This ML algorithm can generate any specific input variables for the laser process while considering predefined electrical properties for supercapacitor.

In conclusion, ML as an optimization method can be used to generate an optimal electrode property for supercapacitors with any predetermined electrochemical properties. In the future direction of this study, other ML methods will be evaluated and the most appropriate model will be proposed for this laser-based technique for fabrication of advanced supercapacitor and battery electrodes.

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