Research & Reviews: Journal of Material Sciences
DOI: 10.4172/2321-6212.S1-004

e-ISSN:2321-6212
p-ISSN:2347-2278

Microstructured Electrodes

Lowy DA*
Sr. Scientist, FlexEl, LLC in College Park, MD, Washington D.C., USA

EDITORIAL

Received date: 01/07/2016
Accepted date: 01/07/2016
Published date: 08/07/2016

***For Correspondence**

Daniel A.Lowy, Sr. Scientist, FlexEl, LLC in College Park, MD, Washington D.C., USA, Tel: +1-703-517 9636

Email: daniellowy@gmail.com

EDITORIAL

Over the past years, microstructured electrodes have contributed significantly to the performance improvement of a wide variety of devices in a wealth of applications. Such electrodes have developed into a mature research field. They provide unprecedented opportunities for artificial intelligence, highly efficient sensors, and novel power sources, ranging from solar cells to asymmetric supercapacitors. Microstructured electrodes enable qualitatively new features or enhance existing features. Among others, they provide better bioelectrocatalysis; examples include polymer/Au nanoparticles composites that serve as catalysts for the electrochemical oxidation of ascorbic acid and as electron-transfer mediators for the activation of common enzymes. Also, microstructured electrodes make it possible to devise elastomeric surfaces with reversible adhesion that can be used in deterministic assembly by transfer printing. Microsturcturing affords the preparation of transparent and neutral color semitransparent electrodes.

Recently, a self-powered analogue smart skin was made based on microstructured poly (dimethylsiloxane) films and silver nanowire electrodes [1]. This flexible smart skin can detect both contact location and velocity of an object with remarkable sensitivity, being able to perceive even the perturbation of a honey bee. It is powered by a triboelectric mechanism, so it does not need batteries.

Perovskite solar cells can be built based on microstructured arrays of perovskite “islands” and transparent electrodes that include thin metallic films, metal nanowires, carbon nanotubes, graphene, and transparent conductive oxides for achieving optical transparency. Such perovskite solar cells generate distinctive color via engineering the band gap of the perovskite light-harvesting semiconductors with chemical management and integrating with photonic nanostructures, including microcavity [2].

Earlier this year, the use of a high-performance Extended-Gate Field-Effect Transistor (EGFET) as pH sensor was reported [3]. Its microstructured sensing head was composed of an oxygen-modified Reduced Graphene Oxide Film (RGOF) on a Reverse-Pyramid (RP) Si structure was developed to achieve a high sensitivity of 57.5mV/pH with an excellent linearity of 0.9929 in a wide pH sensing range of 1-13. These features were ascribed to the large amount of sensing sites and large sensing area. In contrast, the planar Si substrate with the Oxygen-Plasma-Treated RGOF (OPT-RGOF) at the optimal bias power showed a sensitivity of 52.9 mV/pH compared to 45.0 mV/pH for that without plasma treatment. It reveals that oxygen plasma can produce oxygen-containing groups as sensing sites, enhancing proton sensing characteristics. However, oxygen plasma treatment at high bias powers would cause damage to the RGOFs, resulting in poor conducting and sensing properties. On the other hand, the use of the RP structures could increase the effective sensing area and further promote the sensing performance.

Biosensing platforms are in high demand for diagnostic needs of resource-poor areas. Rapid prototyping of application-specific biosensors within hours from design to fabrication would expedite their clinical and field testing. Woo and co-workers demonstrated a benchtop method based on craft cutting and polymer-induced wrinkling, which enabled for multiplexed electrochemical DNA biosensors. This fabrication method can yield multiscale wrinkled electrodes with features on the millimeter to nanometer length scales, within hours. Such wrinkled electrodes have an increased surface area as compared to planar electrodes and are structurally tunable by changing the film thickness. Authors have demonstrated a proof-of-concept electrocatalytic DNA biosensor, which can distinguish between complementary and noncomplementary oligonucleotides [4].

Laser microstructured metal thin films have been demonstrated as an encouraging alternative for indium-tinoxide based transparent electrodes. In order to tailor the optical properties of copper and aluminum thin films (5 to 40 nm thick), micrometer size holes were produced in the films via Direct Laser Interference Patterning (DLIP). The film is processed on the nanosecond or picosecond time frame. This laser treatment increases the optical transmittance of the structured layers by 25-125% and enhances the diffuse to total transmission ratio (HAZE) by 30-82%, without affecting the electrical resistance. Both copper and aluminum comply with the requirements of typical Indium Thin Oxide (ITO) film applications [5].

Additionally, microstructured arrays of perovskite “islands” absorb most visible light, and the combination of completely absorbing and completely transparent regions results in neutral transmission of light. Using such films one can fabricate thin-film solar cells with high power conversion efficiency. These discontinuous films maintain good rectification properties and relatively high open-circuit voltages due to the inherent rectification between the n- and p-type charge collection layers [6].

We are confident that this special issue will provide the readers some illustrative and exciting examples of the manufacturing, characterization, and utilization of microsturctured electrodes. Given the dynamic evolution of this field, we propose to give insight in some recent results, rather than covering the entire topic. Beyond doubt, the field of microstructered electrodes will continue to develop over the coming years, benefitting from contributions made by material scientists, chemists, physicists, and engineers. If experts in the field should find inspiration in the research disclosed here, then we believe we have accomplished the most important goal of this special issue.

REFERENCES

1. Shi MY, et al. Self-Powered Analogue Smart Skin. ACS nano 2016; 10: 4083-4091.
2. Lee KT, et al. Neutral- and Multi-Colored Semitransparent Perovskite Solar Cells. Molecules 2016; 21: 475.
3. Li YR, et al. High-sensitivity extended-gate field-effect transistors as pH sensors with oxygen-modified reduced graphene oxide films coated on different reverse-pyramid silicon structures as sensing heads. Japanese J Appl Phys 2016; 55: 4S.
4. Woo SM, et al. Prototyping of Wrinkled Nano-/Microstructured Electrodes for Electrochemical DNA Detection. Analytical Chem 2014; 86: 12341-12347.
5. Eckhardt S, et al. Laser microstructured metal thin films as promising alternative for indium based transparent electrodes. Optics Express 2016; 24: A553-A568.
6. Eperon GE et al. Neutral color semitransparent microstructured perovskite solar cells. ACS NANO 2014; 8: 591-598.

This article was published under the special issue, **Microstructured Electrodes** handled by Editor. Daniel A.Lowy, FlexEl, LLC in College Park, Washington D.C, USA