High-safety, flexible and scalable rechargeable planar micro-batteries

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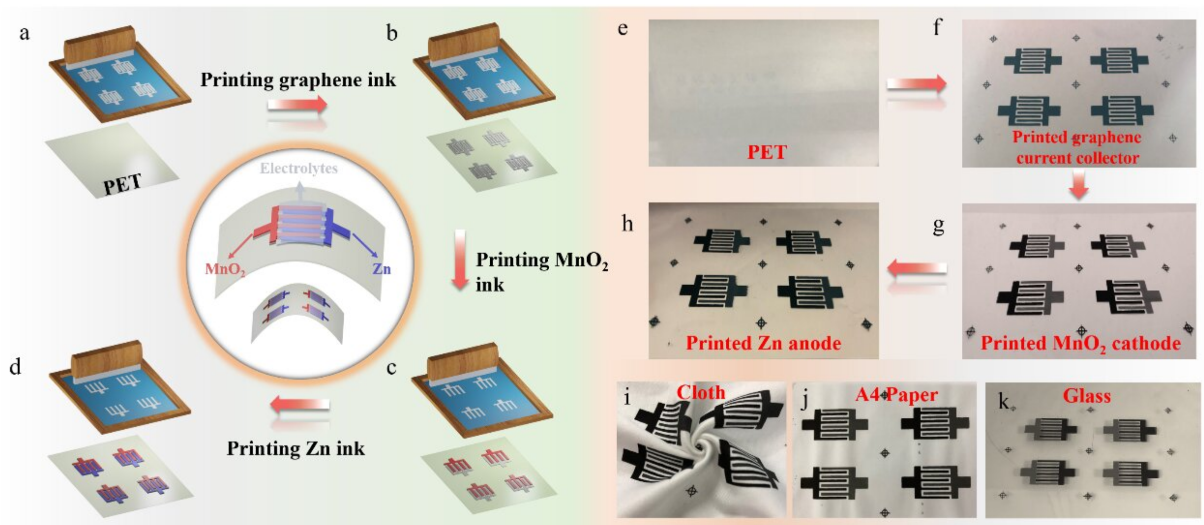

Schematic of screen printing fabrication of printed Zn//MnO2 MBs and Optical photographs showing the stepwise printing fabrication of Zn//MnO2 MBs.(a-d) Schematic of screen printing fabrication of printed Zn//MnO2 MBs: (a) the black PET substrate, (b) the printed graphene current collectors, (c) the printed MnO2 cathode, (d) the printed Zn anode. (e-h) Optical photographs showing the stepwise printing fabrication of Zn//MnO2 MBs: (e) the black PET substrate, (f) the graphene current collectors, (g) the printed MnO2 cathode and (h) the printed Zn anode on the interdigital graphene fingers. (i-k) Zn//MnO2 MBs printed onto the different substrates, including (i) cloth, (j) A4 paper, and (k) glass. Credit: ©Science China Press

Increasing development of micro-scale electronics has stimulated demand of the corresponding micro-scale power sources, especially for micro-batteries (MBs). However, complex manufacturing processes and poor flexibility of the traditional stacked batteries have hindered their practical applications.

Planar MBs have recently garnered attention due to their simple miniaturization, easy serial/parallel integration and capability of working without separator membranes. Furthermore, planar geometry has an extremely short ion diffusion pathway, which is attributed to full integration of printed electronics on a single substrate. Also, in order to get rid of the safety issues induced by the flammable organic electrolyte, the aqueous electrolyte, characterized by intrinsic nonflammability, high ionic conductivity, and nontoxicity, is a promising candidate for large-scale wearable and flexible MB applications. As the consequence, various printing techniques have been used for fabricating planar aqueous MBs. "In particular, screen printing can effectively control the precise pattern design with adjustable rheology of the inks, and is very promising for large-scale application," the author said.

In a new article published in Beijing-based *National Science Review*, Zhong-Shuai Wu at Dalian Institute of Chemical Physics, Chinese Academy of Sciences, constructed aqueous rechargeable planar Zn/MnO_2 batteries by applicable and cost-effective screen printing strategy. "The planar Zn/MnO_2 micro-batteries, free of separators, were manufactured by directly printing the zinc ink as the anode and γ-MnO2 ink as the cathode, high-quality graphene ink as metal-free current collectors, working in environmentally benign neutral aqueous electrolytes of 2 M $ZnSO_4$ and 0.5 M $MnSO_4$," the author stated. Diverse shapes of Zn/MnO_2 MBs were fabricated onto different substrates, implying the potential widespread applications.

The planar separator-free Zn/MnO_2 MBs, tested in neutral aqueous electrolyte, deliver high volumetric capacity of 19.3 mAh/cm3 (corresponding to 393 mAh/g), at 7.5 mA/cm3, and notable volumetric energy density of 17.3 mWh/cm3, outperforming lithium thin-film batteries (

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