Solder-free electrical Joule welding of macroscopic graphene assemblies

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Gold nanoclusters: synthetic strategies and recent advances in uorescent sensing

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Fluorescent gold nanoclusters (AuNCs) have emerged as ideal sensor probes in different research elds such as environmental, biological and clinical applications. AuNCs have acquired a paramount importance in sensing applications owing to their unique physicochemical and luminescence characteristics including excellent photostability and biocompatibility, high surface to volume ratio, besides size-dependent luminescence, large stokes shift, and high emission rates. In this review, we will pay special attention on the recent advances in the different synthetic strategies of AuNCs. Different parameters affecting photoluminescence properties of AuNCs and their quantum yield including AuNCs size, core composition, valence state of Au atoms, and ligand effect will be discussed in detail. This review will also provide a comprehensive and recent look on the various AuNCs-based sensing systems developed for the detection of heavy metal ions, inorganic anions, small biomolecules, protein tumor markers, enzymes, and nucleic acids. This review demonstrates the high sensitivity, selectivity, simplicity, and low cost of AuNCs as sensing probes for the various targeted analytes.

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1. Introduction

Over the past decades, gold nanoparticles (AuNPs) have witnessed a paramount importance in various research areas, including chemical sensing, catalysis, biology, medicine, and environmental sciences [1e4]. AuNPs with size larger than 3 nm exhibit unique optical properties and have distinct feature of surface plasmon resonance (SPR), which results from the resonant collective oscillation of electrons in the conduction band with the incident light. While ultrasmall AuNPs (<3 nm), de ned as gold nanoclusters (AuNCs), have molecular-like properties owing to the strong quantum con nement effect that causes the continuous energy bands break up into discrete energy levels [5,6]. Therefore, AuNCs possess common features, such as HOMO-LUMO transition, photoluminescence (PL), electrochemiluminescence, lacking SPR peak, electromagnetism, redox behavior, and molecular chirality [7e9].

For AuNPs, several recent studies have extensively discussed their controlled synthesis with different sizes (5 e 50 nm), shapes (rods, nanocubes, nanoplates, nano owers, etc), and compositions (alloys such as Au/AgNPs, Au/Cu, Au/Pd,etc). These varied structural features can effectively affect the physical properties of AuNPs by exposing different facets ({110}, {210}, {111}, etc) and different active sites (corners and edges) [6]. Thereby, AuNPs have large surface to volume ratio and excellent catalytic activities toward many reactions, such as oxidation, hydrogenation, and coupling reactions, resulting in its implication in various applications, such as electrocatalysis, solar cells, and biofuel cells. Further, AuNPs have been widely employed in colorimetry, surface-enhanced infrared absorption spectroscopy, and surface-enhanced Raman scattering owing to the unique SPR feature of AuNPs. Unlike AuNCs, AuNPs are non-luminescent nanomaterials, and they can quench NCs luminescence through Förster/ uorescence resonance energy transfer (FRET) owing to high molar absorptivity constant and overlapping of their photoexcitation with AuNCs emission.

For AuNCs, they have ultrasmall size (0.1 nm e 2 nm) consisting of few to several Au atoms; therefore, it is a big challenge to control the core size of AuNCs compared with AuNPs. Different emission

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A brief review on plasma for synthesis and processing of electrode materials

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Plasma, as an active, ionized, and electrically neutral gas, consists of electrons, ions, molecules, radicals,

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Dislocation plasticity reigns in a traditional twinning-induced plasticity steel by *in situ* observation

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To twin or not to twin? The critical doubt emerges recently on the dominant role of deformation twinning in contributing to strain hardening and plasticity, which has been long taken for granted specifically in twinning-induced plasticity (TWIP) steels. Here, the dynamic deformation process was *in situ* studied in a typical Fe-30Mn-3Si-3Al (wt%) TWIP steel by using transmission electron microscopy. It is found that dislocation activities, instead of twinning, reign overall works, which

the core of TWIP effect lies in extraordinary strain hardening by DT serving as a key mechanism, while the negligible dislocation forest hardening is often hinted. Hence, a good balanced result between tensile strength and especially superior ductility is obtained. In addition, the alloys of more or less TWIP effect always induce high fracture toughness and fatigue resistant properties [9 e 12].

Yet, the TWIP effect runs into challenges recently in TWIP steels [13]. Tracing to the TWIP effect, DT contributes to plasticity primarily from the following three aspects [13 e 17]: (1) the formation of deformation twinning accommodates plastic strain; (2) TBs serve as barriers to dislocation motion; and (3) TBs provide adequate sites for nucleating and accommodating dislocations. In contrast, it is long taken for granted that dislocation behaviors are ignorable, even often observable. This idea gets further intensified especially because of the absence of intragranular cross-slip of dislocations, except for planar slip, in varying TWIP steels with face-centered cubic (fcc) structures of low stacking fault energy (SFE). However, the cross-slip of extended dislocations plays a key effect on work hardening, as the dissolved planarity [illegible] intersected cross-slip planes may [illegible] to form Lomer-Cottrell locks, which [illegible]. As such, extraordinarily contributes to work hardening [18]. Actually, DT works through TBs [8,15]. The TBs, if imbedded in grains in advance (e.g. in nanotwinned metals), realize strain hardening by intensifying dislocation-mediated plasticity to produce dislocation generation and strong interplay with TBs. Yet, both the density and spacing of TBs in TWIP steels are usually at least one magnitude lower than that in nanotwinned metals [19,20]. Thereby, the dislocation plasticity may operate freely. Recently, a few results spring up to question whether or not DT indeed plays the dominant role in strain hardening in TWIP steels. For example, it is the forest hardening instead of DT that contributes to up to 90% of flow stress in a Fe-18Mn-0.6C-1.5Al-0.8Si (wt. %) TWIP steel [21]. In a Fe-22Mn-0.6C TWIP steel, DT happens only in part of grains because of orientation anisotropy [14,22]. The quantitative measurement

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Exploration of nanowire- and nanotube-based electrocatalysts for oxygen reduction and oxygen evolution reaction

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a b s t r a c t

Electrocatalysts for oxygen reduction and/or evolution are key components for proton-exchange membrane fuel cells (PEMFCs) and water electrolysis. However, the slow kinetics of oxygen reduction and/or evolution reactions largely hampers the ef ciencies of PEMFCs and water electrolysis. Highly ef cient electrocatalysts for oxygen reduction and evolution reactions must meet three requirements: (i) rapid transport of electrons, ions, and products of the reaction; (ii) suf cient catalysts/reactants contact area; and (iii) good intrinsic activity. Nanostructuration of electrocatalysts provides an effective approach to overcome the slow kinetics because nanostructured electrocatalysts with rational design can not only provide suf cient active sites but also promote intrinsic activity of electrocatalysts as well as possess the ability of rapid transport of electrons, ions, and products of the reaction. Especially, electrocatalysts in the form of one-dimensional nanostructures (1D-Nano) such as nanowires (NWs) and nanotubes (NTs) have shown signi cant advantages, such as high surface area, rapid electron and mass transfer, low vulnerability to dissolution, Ostwald ripening, and aggregation, for oxygen evolution reaction (OER) and oxygen reduction reaction (ORR). In this review, we summarize different strategies for fabricating 1D nanostructure-based electrocatalysts (1D-NanoECs), which are categorized into template-free and template-assisted strategies, and emphasis has been placed on anodic aluminum oxide template e assisted strategies. Then, recent advances of 1D-NanoECs for ORR and OER applications are summarized. Finally, future challenges and opportunities about 1D-NanoECs are discussed.

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1. Introduction

Similar to batteries, fuel cells use the chemical energy of fuels to produce electric energy, but the signi cant difference is that fuel cells have much faster charging time. For example, vehicles powered by hydrogen fuel cells can be fully refueled within only 3 min, while lithium-ion batteries-based vehicles need at least a few hours. What' more, hydrogen fuel cells have high energy density of 142 MJ/kg, which is more than 200 times that of lithium-ion batteries (0.6 MJ/kg). Especially, fuel cells are also marked by higher ef ciencies and no environmental pollution compared with the internal combustion engines [1e3]. Based on these advantages, fuel cells have been widely used in the elds of stationary and portable power devices.

Among various kinds of fuel cells, proton-exchange membrane fuel cells (PEMFCs) have obvious superiorities, including high simplicity, low working temperature (50 e100 C), high power density, and quick start-up [1,4,5]. In the PEMFC system, H_2 is oxidized at the anode surface to produce electrons and protons that are transferred to the cathode through an external circuit and the proton-exchange membrane, respectively (as shown in Fig. 1). Meanwhile, O_2 is slowly reduced at the cathode surface by reacting with protons and electrons to produce H_2O. Considering the multistep reactions in the PEMFC system, three key issues are still needed to be addressed to further improve its ef ciency. (i) The oxygen reduction reaction (ORR) rate is six or more orders of magnitude slower than that of hydrogen oxidation reaction at the anode and thus signi cantly restricts the rate of the whole PEMFC system [6]. (ii) Most commercial electrocatalysts for ORR are based on Pt with high cost, leading to the increasing price of large-sale PEMFC. (iii) The adequate hydrogen production cannot be satis- ed, which is a determinative prerequisite for realizing massive utilization of fuel cells. Therefore, the discovery of high-ef ciency and cost-effective electrocatalysts for ORR is critical to improving the overall PEMFC performance. Regarding the inadequate hydrogen

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Polymers of intrinsic microporosity for energy-intensive membrane-based gas separations

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This review provides a new perspective on the role of the state-of-the-art polymers of intrinsic microporosity (PIMs) in key energy-intensive membrane-based gas separations including O_2/N_2, H_2/N_2, H_2/CH_4, CO_2/CH_4, H_2S/CH_4, C_2H_4/C_2H_6, and C_3H_6/C_3H_8 applications. A general overview on the gas separation properties of novel PIM materials developed in the past 15 years is presented with updated performance maps on the latest pure-gas 2015 O_2/N_2, H_2/N_2, and H_2/CH_4 permeability/selectivity upper bounds. Specifically, functionalized ladder PIMs and polyimides of intrinsic microporosity (PIM-PIs) are discussed targeting at high-performance, plasticization-resistant membranes for demanding acid gas (CO_2 and H_2S) removal from CH_4 in natural gas and olefin/paraffin separations. Experimental CO_2/CH_4 performance data of nearly 70 polymeric membrane materials available in the literature were gathered and plotted for the first time on the Robeson plot, from which a mixed-gas 2018 CO_2/CH_4 upper bound was proposed to provide guidance for future membrane materials development. A number of PIMs have demonstrated outstanding performances in O_2/N_2, H_2/N_2, and H_2/CH_4 separations, and several functionalized PIMs have shown great promises in CO_2/CH_4 separation under realistic mixed-gas conditions. The potential of PIMs materials and their derivatives for H_2S/CH_4, C_2H_4/C_2H_6, and C_3H_6/C_3H_8 separations are underexplored, and significant efforts are needed to develop stable and high-performance materials under mixed-gas conditions. Ultimately, fabricating PIMs materials into defect-free, inexpensive, thin-film composite or integrally-skinned asymmetric membranes is paramount to their successful large-scale commercialization.

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1. Introduction

Industrial separation processes account for a significant fraction of the global energy consumption. Large energy consumption drives the demand to improve the process energy efficiency and