catalysts

MDPI

Review

SUPPLEMENTARY MATERIAL

Metal Nanotube/Nanowire-Based Unsupported Network Electrocatalysts

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Table S1. Summary of the nano-network examples discussed in section 2.1 (2D nano-networks, preparation from colloidal building blocks).

Ref.	Nanomaterial	Fabrication	Application
[14]	merged Ag nanowire film	colloidal Ag nanowire synthesis; drop casting + rolling; electroless plating	transparent conductor
[30]	aligned Ag nanowire film	colloidal Ag nanowire synthesis; interfacial assembly	surface-enhanced Raman spectroscopy
[36]	merged Ag nanowire film	commercial Ag nanowires; spray coating; halide welding	transparent conductor
[37]	merged Ag nanowire film	colloidal Ag nanowire synthesis; drop casting; plasmonic welding	transparent conductor
[38]	merged Ag nanowire film	colloidal Ag nanowire synthesis; drop casting; heat treatment / mechanical pressing	transparent conductor
[39]	Ag nanowire film	commercial Ag nanowires; membrane filtration; membrane collapse	transparent, flexible H_2O_2 sensor electrode
[40]	graphene-coated Cu nanowire film	colloidal Cu nanowire synthesis; membrane filtration + nanowire transfer; chemical vapor deposition of carbon	transparent electrode for hydrogen evolution
[41]	Cu-Pt core-shell nanowire film	colloidal Cu nanowire synthesis; nanowire ink preparation + rolling + pressing; plasma cleaning; Pt electrodeposition	transparent electrode for hydrogen evolution
[42]	colloidal Pd nano-mesh	colloidal Pd nano-sheets; chemical etching	ethanol electrooxidation

Table S2. Summary of the nano-network examples discussed in section 2.2 (2D nano-networks, template-assisted deposition).

Ref.	Nanomaterial	Fabrication	Application
[45]	Cu / Ag nanofiber film	electrospinning of polymer-$SnCl_2$ nanofibers; fiber seeding in $AgNO_3$ solution; electroless Cu / Ag plating	transparent conductor
[46]	Pd nanowire film	anodized nanoporous Al substrate; Pd sputtering	resistive H_2 sensor
[47]	metal nanotrough film	electrospinning of polymer nanofibers; thermal / electron beam evaporation of various metals	transparent conductor
[48]	Pt nanowire film	electrospinning of polymer-H_2PtCl_6 nanofibers; heat treatment	catalytic conductive transparent solar cell electrodes
[49]	Au nanowire mesh	grain boundary lithography + Au electron beam evaporation	transparent stretchable conductors
[50]	ordered, optionally crossed Au nanowire layers	replication of periodic Si master grating with polymer; Au sputtering	metallic photonic crystals

Table S3. Summary of the nano-network examples discussed in section 3.1 (3D nano-networks, preparation from individual 1D nanostructures).

Ref.	Nanomaterial	Fabrication	Application
[51]	Cu nanowire layer	colloidal Cu nanowire synthesis; drop casting; Nafion binder addition	electrochemical glucose detection
[52]	Prussian blue modified Ag nanowire layer	colloidal Ag nanowire synthesis; drop casting on electrode with dithiol linker; Prussian blue aerosol deposition	electrochemical H_2O_2 and glucose detection
[53]	Ag nanowire layer	colloidal Ag nanowire synthesis; drop casting with Nafion binder	electrochemical CO_2 reduction / hydrogen evolution
[55]	Pt nanotube layer	colloidal Ag nanowire synthesis; galvanic exchange; drop casting; Nafion binder addition	methanol electrooxidation
[56]	Pd-Pt nanotube layer	colloidal Ag nanowire synthesis; galvanic Pd/Pt exchange; drop casting; Nafion binder addition	oxygen reduction reaction
[57]	Pt-Cu nanotube layer	colloidal Cu nanowire synthesis; galvanic Pt exchange; acid treatment; drop casting; Nafion binder addition	oxygen reduction reaction
[58]	Pd / Au nanotube layer	colloidal Ag nanowire synthesis; galvanic exchange; drop casting	electrochemical oxidation of various alcohols, oxygen reduction reaction
[59]	Pt-Au nanotube layer	colloidal Te nanowire synthesis; galvanic Au/Pt exchange; drop casting; Nadion binder addition	methanol electrooxidation
[60]	Pt-Ru nanotubes / Pt-Ru-Cu nanowire layer	colloidal Cu nanowire synthesis; complete / partial galvanic Pt/Ru exchange; drop casting	methanol electrooxidation
[61]	double-walled Ag-Pt nanotube layer	template-assisted electroless synthesis of Ag nanotubes; template dissolution; galvanic Pt exchange; variable Ag etching; drop casting	methanol electrooxidation
[64]	Pt / Pt-Ru nanotube layer	template-assisted electroless Pt plating; optional Ru deposition; template dissolution on electrode	methanol electrooxidation
[65]	layer built from micro- / mesoporous Rh nanotubes	template-assisted electroless Rh plating; template dissolution; drop casting	electrochemical H_2O_2 detection
[66]	layer built from solid / porous Au nanotubes	template-assisted electroless Au plating; template dissolution on electrode	electrochemical H_2O_2 detection
[68]	Pt-Ru nanotube layer	template-assisted chemical vapor deposition of Pt and hydrous Ru oxide; optional annealing; template dissolution; drop casting	methanol electrooxidation
[72]	Pd-Au-Cu nanotube layer	template-assisted multi metal electrodeposition from DMSO electrolyte; template dissolution; drop casting with Nafion binder	oxygen reduction reaction / electrochemical H_2O_2 reduction
[74]	Pt-Ni nanowire layer	commercial Ni nanowires; galvanic Pt exchange; optional Ni leaching; ink	H_2 / O_2 fuel cell

		preparation with Nafion; spray coating on fuel cell membrane	
[75]	3D Ag nanowire aerogel	commercial Ag nanowires; nanowire suspension in H_2O with surfactant; gelation via solvent evaporation; supercritical drying	-
[76]	3D Cu nanowire aerogel	colloidal Cu nanowire synthesis; gelation with increasing nanowire density; freeze-drying	fluid wicking
[77]	3D Pd nanowire aerogel	template-assisted Pd nanowire electrodeposition; template removal; nanowire suspension in H_2O; shock freezing; freeze-drying	H_2 storage

Table S4. Summary of the nano-network examples discussed in section 3.2 (3D nano-networks, template-assisted deposition).

Ref.	Nanomaterial	Fabrication	Application
[2]	interconnected Pt nanowires	Pt electrodeposition in ion-track etched polymer template; template dissolution	methanol electrooxidation
[13]	interconnected metal nanotube networks	electroless plating of various metals onto ion-track etched polymer templates; template dissolution	electrochemical H_2O_2 detection
[63]	Cu / Cu-Ni / Cu oxide (core-shell) nanotube networks	electroless Cu plating of commercial ion-track etched templates with widened pores; template dissolution; optional derivatization	electrochemical glucose detection
[84]	interconnected Ni nanowires	Ni electrodeposition in alumina template; template dissolution	-
[85]	parallel / interconnected Ni-Sn nanowires	Ni-Sn electrodeposition in alumina template variants; template dissolution	lithium ion battery anode
[86]	parallel / interconnected Ni nanowires	Ni electrodeposition in alumina template variants; template dissolution	-
[90]	hierarchical, interconnected metal microwire / nanowire / nanotube networks	electroless plating / electrodeposition combined with hierarchically porous ion-track etched templates; template removal	electrochemical H_2O_2 detection
[92]	interconnected Ni / Ni-B nanotube arrays	electroless Ni / Ni-B plating of ion-track etched PET template with planar voids; template dissolution	ethanol electrooxidation
[98]	interconnected porous Pt nanotubes	electroless Pt plating of ion-track etched polymer template; template dissolution	methanol electrooxidation
[103]	interconnected Ni / Ni-NiO / NiO (core-shell) nanowires	Ni electrodeposition in ion-track etched polymer template; template dissolution; thermal oxidation	lithium ion microbattery
[104]	interconnected Ni nanowires	Ni electrodeposition in ion-track etched polymer template; template dissolution	magnetism / microwave absorption studies
[105]	interconnected Ni / NiCo / Co nanowires	Ni / Ni-Co / Co electrodeposition in ion-track etched polymer template; template dissolution	magnetism studies
[106]	interconnected Ni-Fe / Co nanowires	Ni-Fe / Co electrodeposition in ion-track etched polymer template; template dissolution	magnetism studies
[107]	interconnected Ni nanotubes	core-shell-segregated Ni-Cu electrodeposition in ion-track etched polymer template; selective Cu dissolution; template dissolution	magnetism studies
[111]	interconnected Pt nanotubes	electroless Pt plating of commercial ion-track etched polymer template; template dissolution	methanol electrooxidation
[112]	interconnected Cu nanowires	Cu electrodeposition in commercial ion-track etched polymer template; template dissolution	heat transfer

[113]	fragmented network of interconnected Au nanowires	electroless Au plating of commercial ion-track etched polymer template; template dissolution; drop casting	live monitoring of a catalytic reaction (nitrophenol reduction) *via* surface enhanced Raman spectroscopy
[114]	fragmented network of interconnected Au nanotubes	electroless Au plating of commercial ion-track etched polymer template; template dissolution; drop casting	nanoelectrode ensemble (performed with template-embedded / -stabilized nanostructures)
[116]	interconnected porous Pt nanowires	electrodeposition of Pt-Cu in commercial ion-track etched template; termplate dissolution; Cu dealloying; immobilization of glucose oxidase	electrochemical H_2O_2 / glucose detection

Table S5. Summary of the nano-network examples discussed in section 3.3 (3D nano-networks, nanofiber networks prepared by electrospinning).

Ref.	Nanomaterial	Fabrication	Application
[127]	Pt nanowire web	electrospinning of polymer-H_2PtCl_6 nanofibers; heat treatment	methanol electrooxidation
[128]	Fe / Co / Ni nanowire webs / aligned arrays	electrospinning of polymer-metal nitrate nanofibers; polymer pyrolysis + reduction treatment	magnetism studies
[129]	Ir-Ru-oxide nanowire web (partial *in situ* reduction during application)	electrospinning of polymer-metal chloride nanofibers; heat treatment	hydrogen evolution reaction
[131]	Pt-Co nanotube web	electrospinning of polymer-H_2PtCl_6-$Co(NO_3)_2$ nanofibers; polymer pyrolysis + reduction treatment; partial Co dealloying	oxygen reduction reaction
[132]	Ag-Co nanotube web	electrospinning of polymer-$Co(NO_3)_2$ nanofibers; polymer pyrolysis + reduction treatment; galvanic Ag exchange	oxygen reduction reaction
[133]	Au-nanofilm-coated microfiber web	electrospinning of polymer-$HAuCl_4$ microfibers; Au seed generation by $NaBH_4$ reduction; electroless Au plating; fructose dehydrogenase immobilization	electrochemical fructose detection
[135]	web composed of porous / solid Ag nanotubes	Ag sputtering onto polymer nanofiber template; nanofiber dissolution; optional plasma etching treatment	surface enhanced Raman spectroscopy
[136]	web composed of porous Pt-Fe nanowires	electrospinning of polymer-H_2PtCl_6-$Fe(NO_3)_3$ nanofibers; polymer pyrolysis + reduction treatment; selective Fe dissolution	oxygen reduction reaction
[138]	web composed of porous Pt nanotubes	electrospinning of polymer-H_2PtCl_6 nanofibers; heat treatment	dye-sensitized solar cell electrode
[139]	web composed of mesoporous Au nanotubes	Ag sputtering onto polymer nanofiber template; nanofiber dissolution; galvanic Au exchange	surface enhanced Raman spectroscopy
[140]	Pt nanowire web	electrospinning of polymer-H_2PtCl_6 nanofibers; heat treatment	- (optimization of electrospinning conditions for realizing ultrathin Pt nanowires, intended use: fuel cells)