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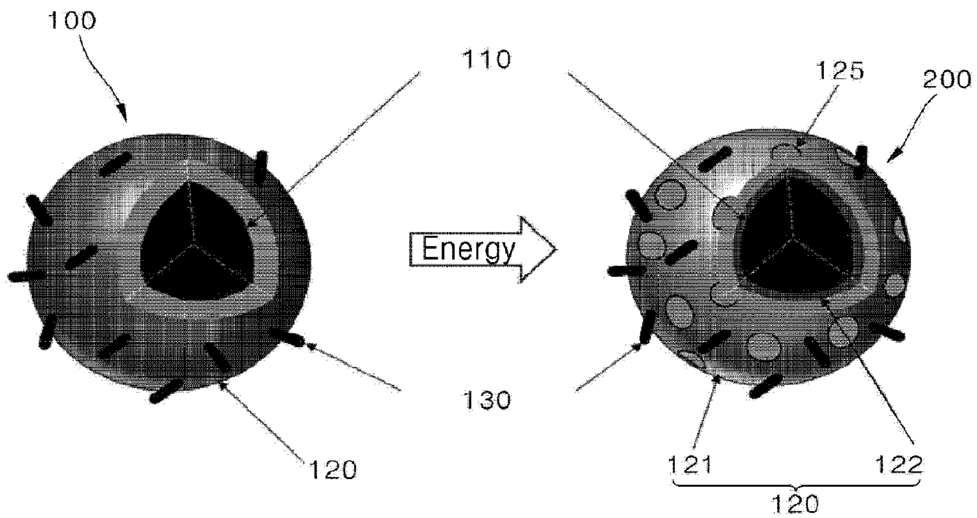
(54) **Titre : ELECTRODE POUR BATTERIE SECONDAIRE AU LITHIUM AYANT UN MATERIAU ACTIF ENCAPSULE ET SON PROCEDE DE FABRICATION**
(54) **Title: ELECTRODE FOR LITHIUM SECONDARY BATTERY HAVING ENCAPSULATED ACTIVE MATERIAL AND METHOD OF MANUFACTURING THE SAME**



(57) **Abrégé/Abstract:**
The present disclosure relates to a method for manufacturing an electrode for a lithium secondary battery having encapsulated active material using energy application, and the method helps to minimize the volume change of an electrode or negative side effects, such as high internal stress, a fracture, pulverization, delamination, electronic isolation from a conductive agent, the formation of an unstable solid-electrolyte interphase, and a loss of energy capacity of the batteries.

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【ABSTRACT】

The present disclosure relates to a method for manufacturing an electrode for a lithium secondary battery having encapsulated active material using energy application, and the method helps to minimize the volume change of an electrode or negative side effects, such as high internal stress, a fracture, pulverization, delamination, electronic isolation from a conductive agent, the formation of an unstable solid-electrolyte interphase, and a loss of energy capacity of the batteries.

【ABSTRACT】

The present disclosure relates to a method for manufacturing an electrode for a lithium secondary battery having encapsulated active material using energy application, and the method helps to minimize the volume change of an electrode or negative side effects, such as high internal stress, a fracture, pulverization, delamination, electronic isolation from a conductive agent, the formation of an unstable solid-electrolyte interphase, and a loss of energy capacity of the batteries.

【CLAIMS】

【Claim 1】

A method of manufacturing an electrode for a lithium secondary battery, comprising:

mixing active materials, polymeric binders, carbon-based additives and a solvent;

encapsulating the active materials by the polymeric binders; and

carbonizing part of the polymeric binders and generating nanopores in the polymeric binders via energy application to the polymeric binders.

【Claim 2】

The method of claim 1, wherein an outer hard shell and an inner soft shell are formed from the polymeric binder via the carbonization.

【Claim 3】

The method of claim 1, wherein the active materials comprise one or more of silicon, silicon oxide, silicon carbide, magnesium silicide, a silicon-iron-manganese alloy, manganese silicate, a silicon alloy, aluminum, tin, Li_xSi-Li_2O core-shell nanoparticles, or sulfur.

【Claim 4】

The method of claim 1, wherein the polymeric binder comprises a first polymer having a low boiling point, and a second or third polymer having a boiling point higher than that of the first polymer, wherein the polymeric binder include two or more of polyacrylonitrile (PAN), polytetrafluoroethylene (PTFE), poly(methyl methacrylate; PMMA), poly(3,4-ethylenedioxythiophene) polystyrene sulfonate (PEDOT:PSS), polydiacetylenes (PDA), polypropylene (PP), polystyrene (PS), polyurethane (PU), polyethylene oxide (PEO), polyethylene terephthalate (PET), Styrene-ethylene-butylene-styrene (SEBS), glycerol, asphaltene, meso-phase pitch, sucrose, cellulose, and lignin.

【Claim 5】

The method of claim 4, wherein the first polymer evaporates via the energy application, and nanopores are formed via the evaporation.

【Claim 6】

The method of claim 1, wherein the polymeric binder comprises double network hydrogels.

【Claim 7】

The method of claim 6, wherein the double network hydrogels are selected from carboxylmethyl cellulose (CMC), polyvinyl alcohol (PVA), and polyacrylic acid (PAA), polyacrylic acid (PAA) and polyethylene glycol (PEG), polyacrylic acid (PAA) and polyethylenimine (PEI), polyacrylic acid (PAA) and chitosan, a styrene/butadiene copolymer (SBR), polymethyl methacrylate (PMMA) and a combination thereof.

【Claim 8】

The method of claim 1, wherein the polymeric binders comprise polymers with elements of active materials.

【Claim 9】

The method of claim 8, wherein the polymers with elements of active materials comprise organosilicon selected from polysiloxane, polysilsesquioxane, polycarbosiloxane, polyborosiloxane and polysilicarbodiimide and sulfur-containing polymers selected from polysulfoxide and poly (sulfur nitride), and

some of the polymers with elements of active materials are converted into one or more of SiOC (silicon oxycarbide), SiC (silicon carbide), SiBCN (silicoboron carbonitride), SiCN (silicon carbonitride), SC (sulfur-carbon composite), or SCN (thiocyanate) via energy application.

【Claim 10】

The method of claim 1, wherein the polymeric binders can comprise piezoelectric polymers.

【Claim 11】

The method of claim 10, wherein the piezoelectric polymers comprise one or more of polyvinylidene fluoride (PVDF), polyvinylidene fluoride trifluoroethylene (PVDF-TRFE), and parylene-C.

【Claim 12】

The method of claim 1, wherein the carbon-based additives comprise one or more of single-walled carbon nanotubes (SWCNTs), multi-walled carbon nanotubes (MWCNTs), thin-walled carbon nanotubes (TWCNTs), carbon fibers, graphene, graphene oxides, and carbon dots.

【Claim 13】

The method of claim 1, wherein the solvent comprises water, N-methyl-2-pyrrolidone (NMP), dimethylformamide (DMF), dimethyl sulfoxide (DMSO), or a combination thereof.

【Claim 14】

The method of claim 1, wherein the encapsulation of active materials comprises preparing a slurry mixture comprising active materials, polymeric binders, carbon-based additives and solvents, generating droplets via nebulisation, and

drying the droplets in an air-suspended chamber by using a heater while circulating the droplets in air.

【Claim 15】

The method of claim 1, wherein the energy application is performed in a power state, in an electro-spun fiber state or in a state of being applied to an electrode collector.

【Claim 16】

The method of claim 1, wherein in the energy application, one or more of intense pulsed light, a laser, microwaves and Joule's heat are used.

【Claim 17】

The method of claim 1, wherein a carbon precursor material selected from pitch, mesophase pitch, isotropic pitch, and asphaltene is additionally mixed to form a composite of carbon and silicon, silicon oxide or silicon carbide.

【Claim 18】

The method of claim 1, further comprising, one or more pre-lithiation procedures selected from the following steps:

a. pre-lithiating active materials in a powder form before encapsulation and carbonization processes;

b. pre-lithiaiting active materials in a powder form after encapsulation and carbonization processes;

c. pre-lithiating electrodes after electrode manufacturing and carbonization processes;

d. pre-lithiating electrodes by direct contact with lithium metal on the electrodes; and

e. pre-lithiating active materials in a powder form through reduction of lithium by applying energy treatment to lithium salts.

【Claim 19】

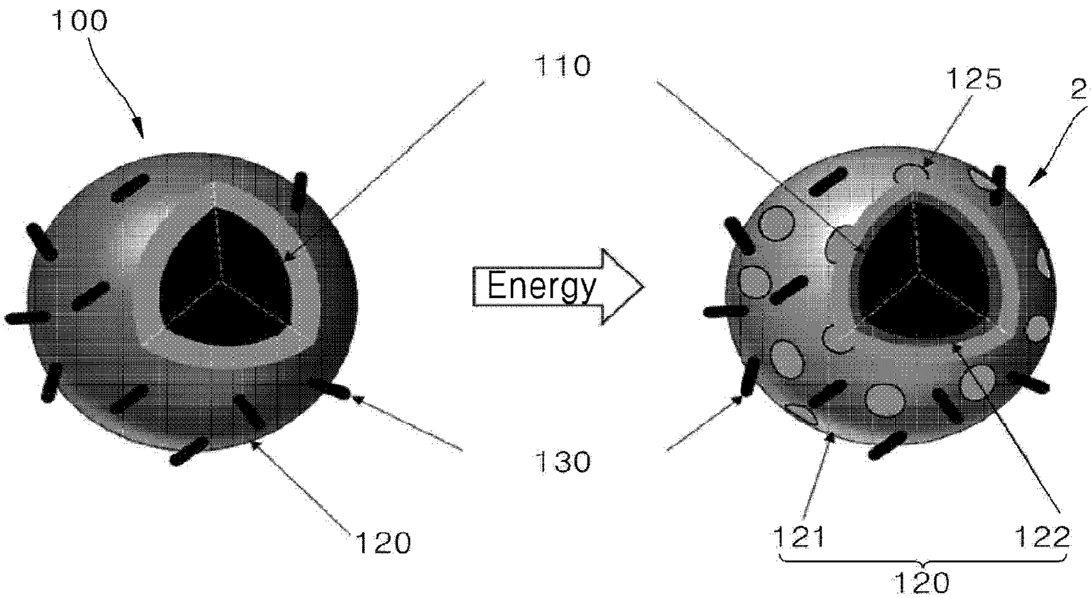
An electrode for a secondary battery, comprising; active materials, polymeric binders and carbon-based additives,

wherein the active materials are encapsulated by the polymeric binders,
some of the polymeric binders are carbonated,
the carbon-based additives are dispersed in the polymeric binders, and
the polymeric binders have nanopores.

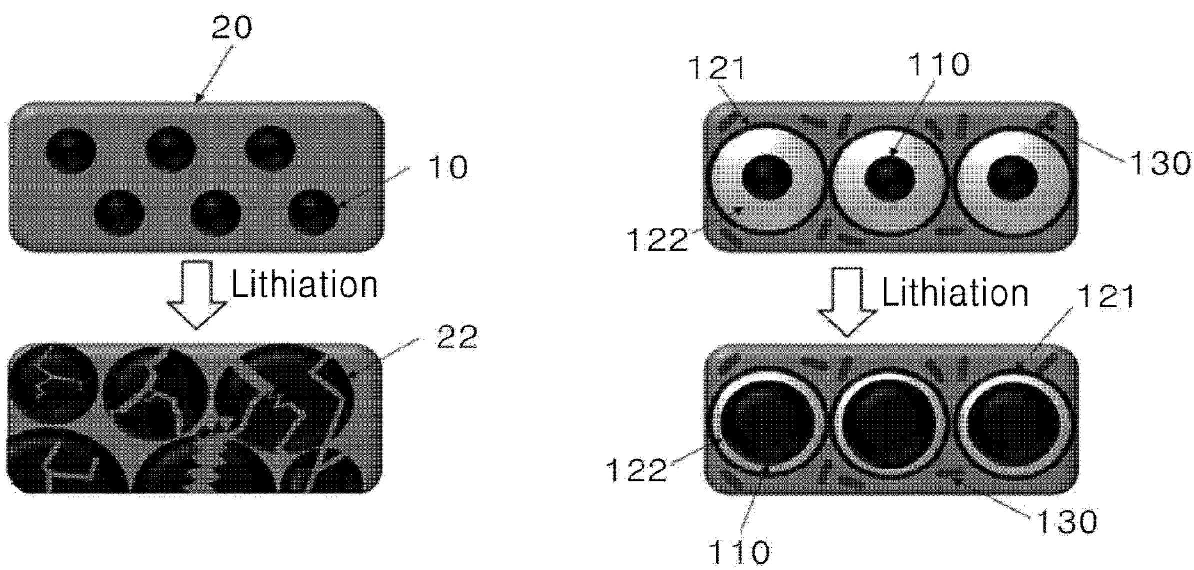
【Claim 20】

The electrode of claim 19, wherein the polymeric binder comprises an outer hard shell

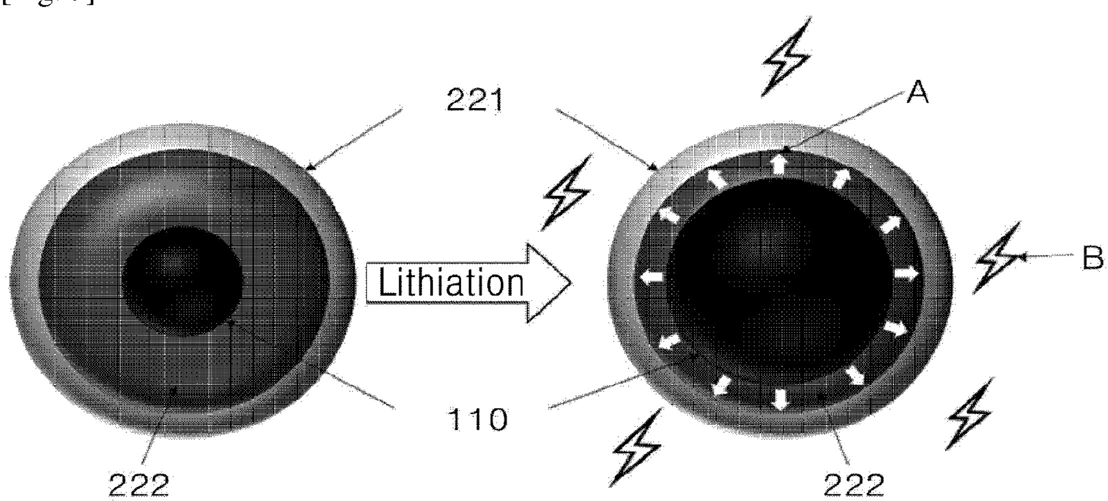
[Fig. 1]



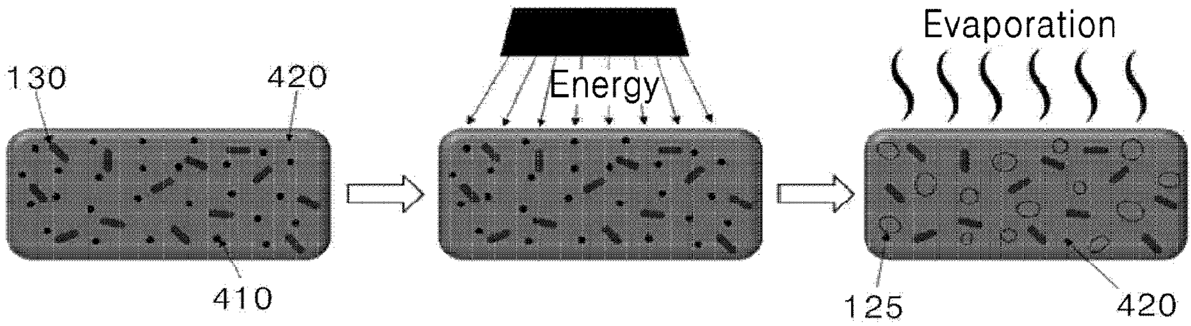
[Fig. 2]



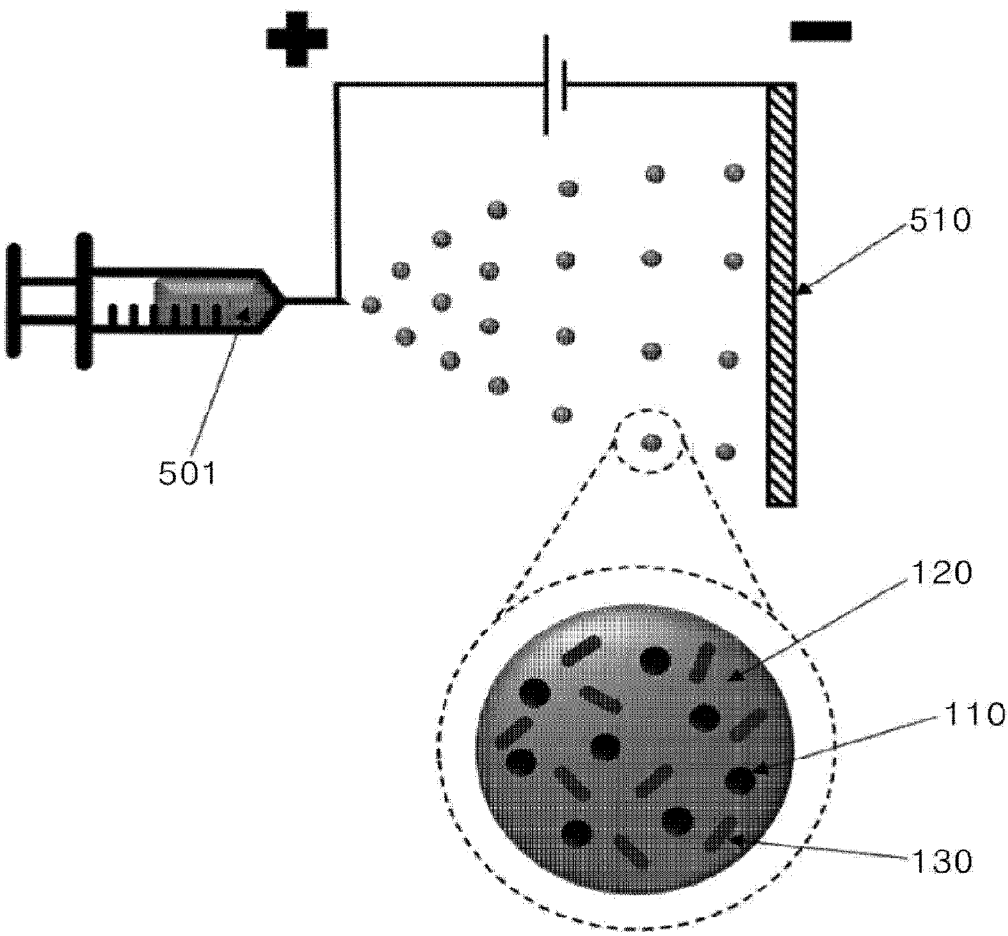
[Fig. 3]



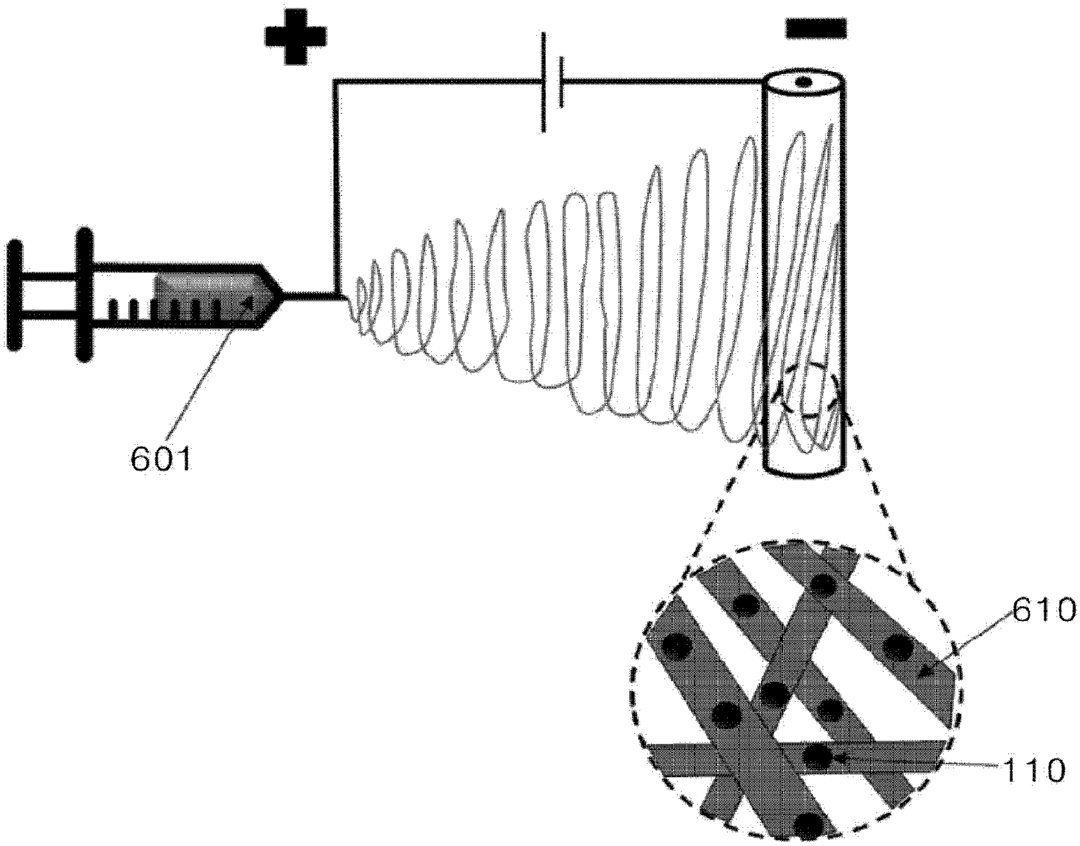
[Fig. 4]



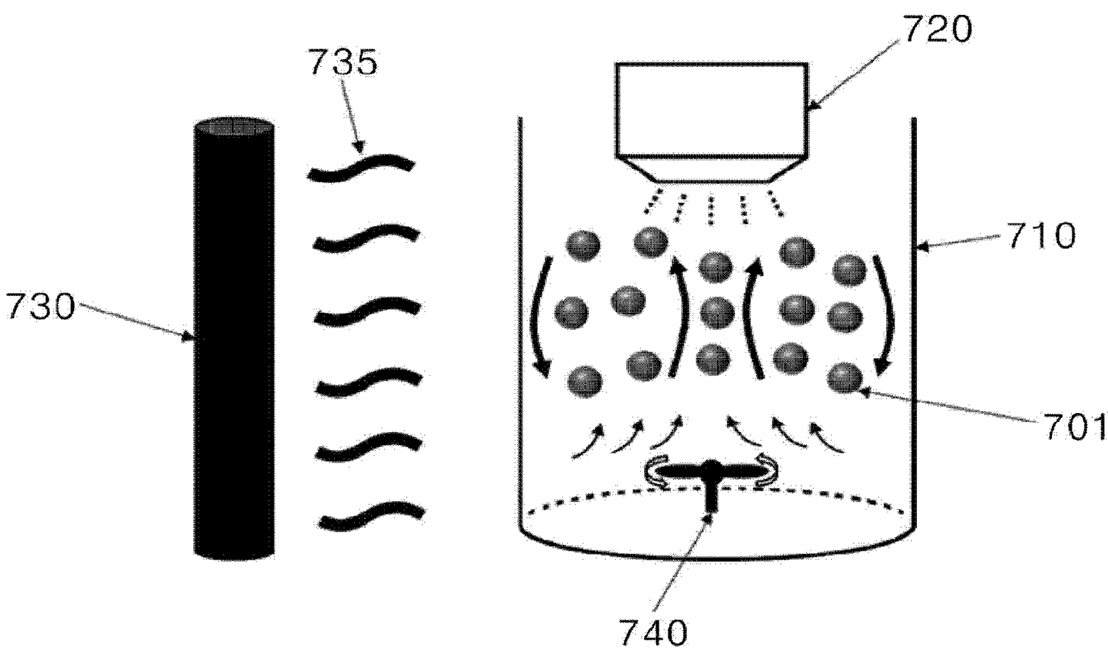
[Fig. 5]



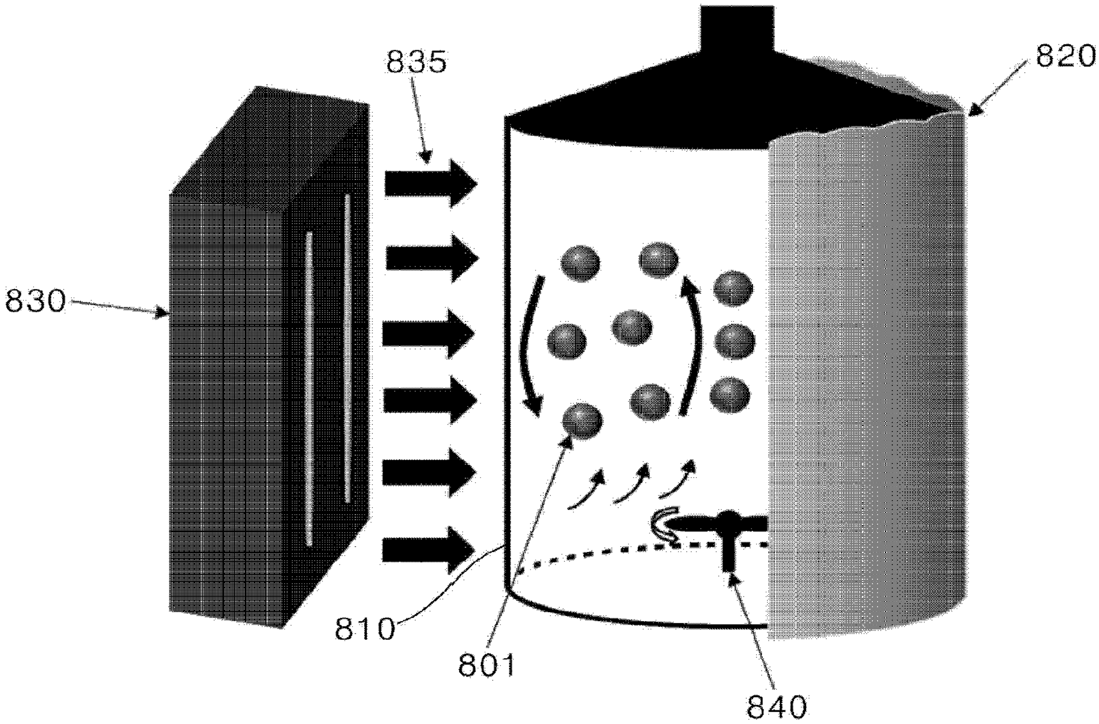
[Fig. 6]



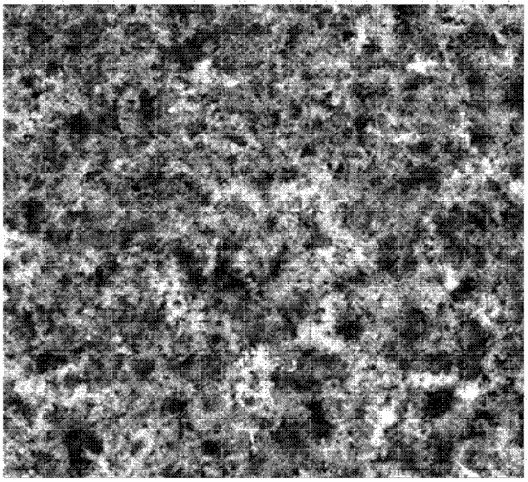
[Fig. 7]



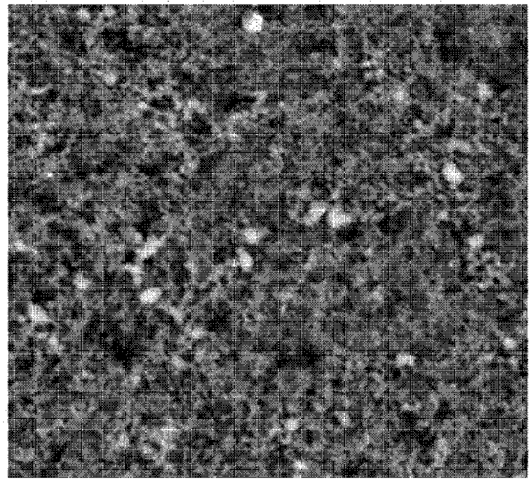
[Fig. 8]



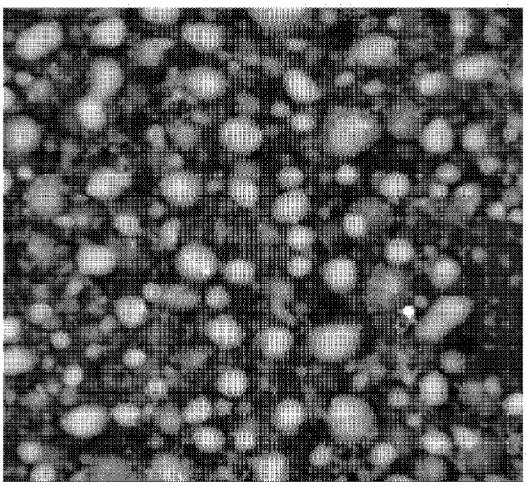
[Fig. 9]



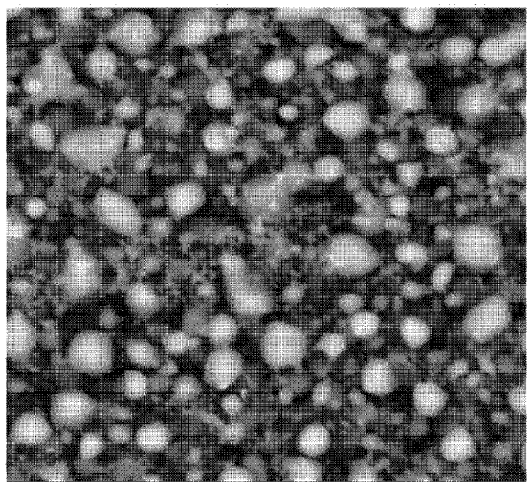
(a) Before IPL



(b) 1 pulse IPL treatment

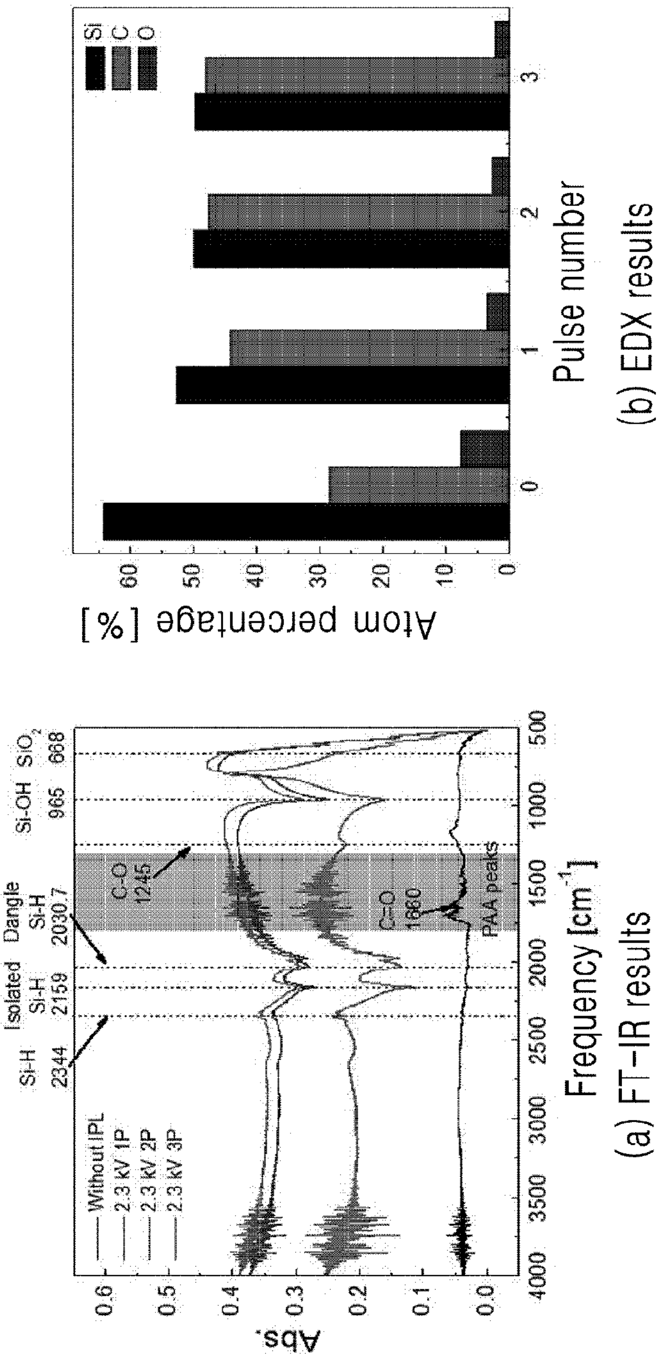


(c) 2 pulse IPL treatment



(d) 3pulse IPL treatment

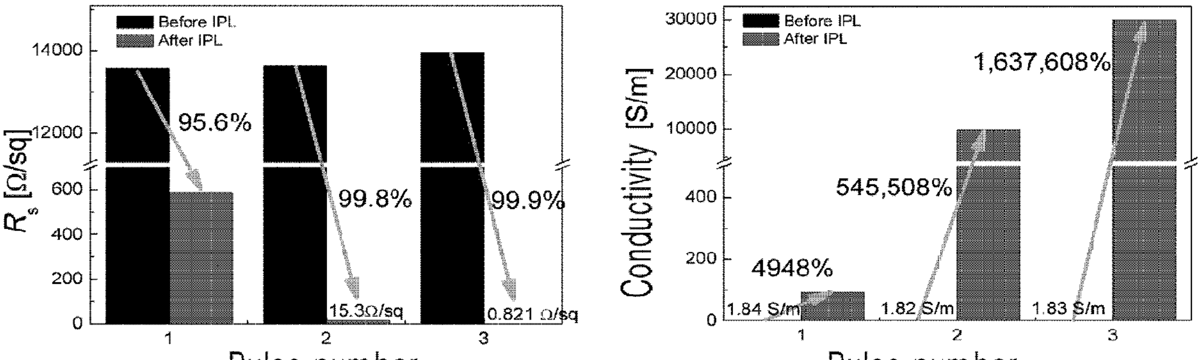
[Fig. 10]



(a) FT-IR results

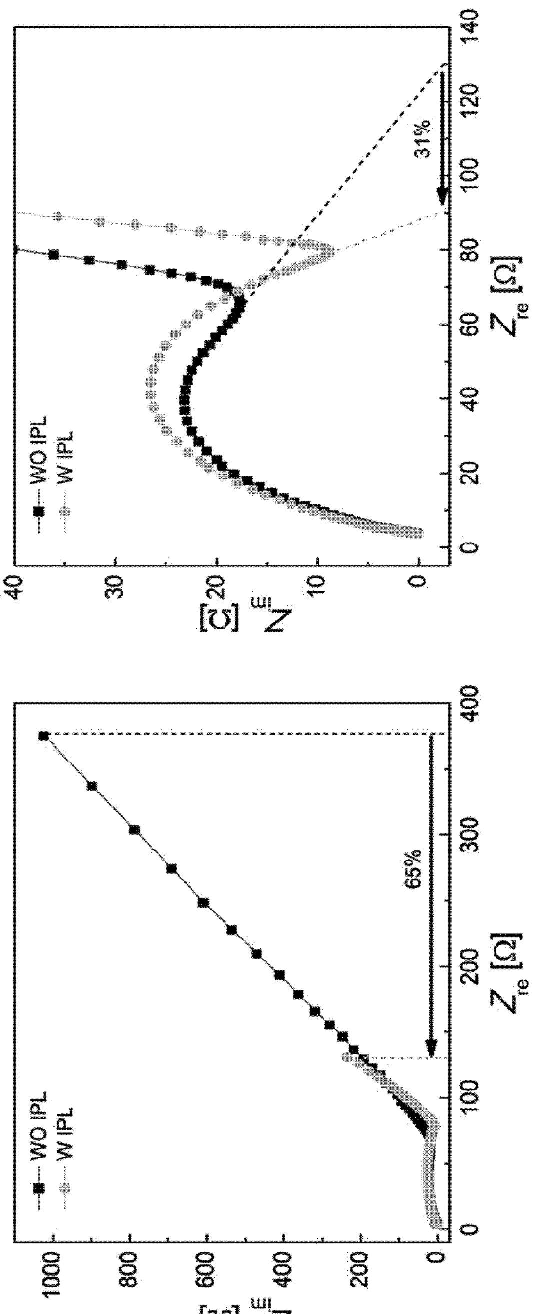
(b) EDX results

[Fig. 11]



(a) Improvement in surface resistance (b) Improvement in conductivity

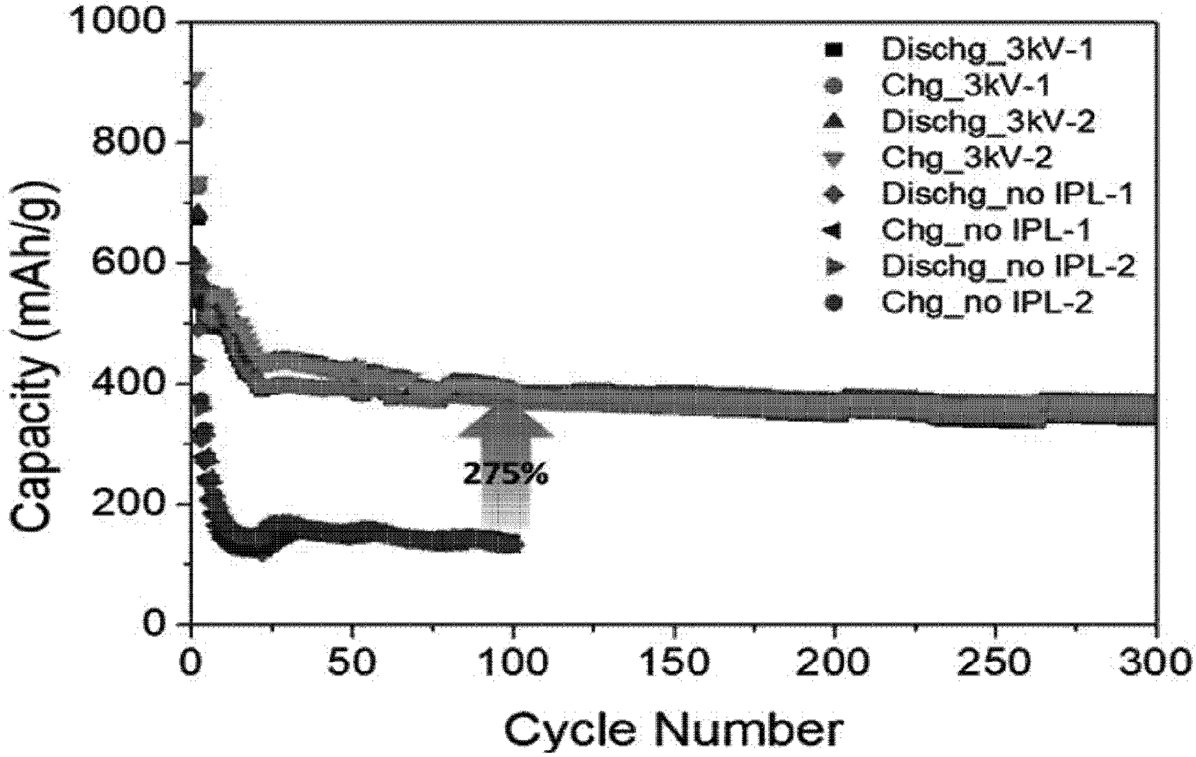
[Fig. 12]



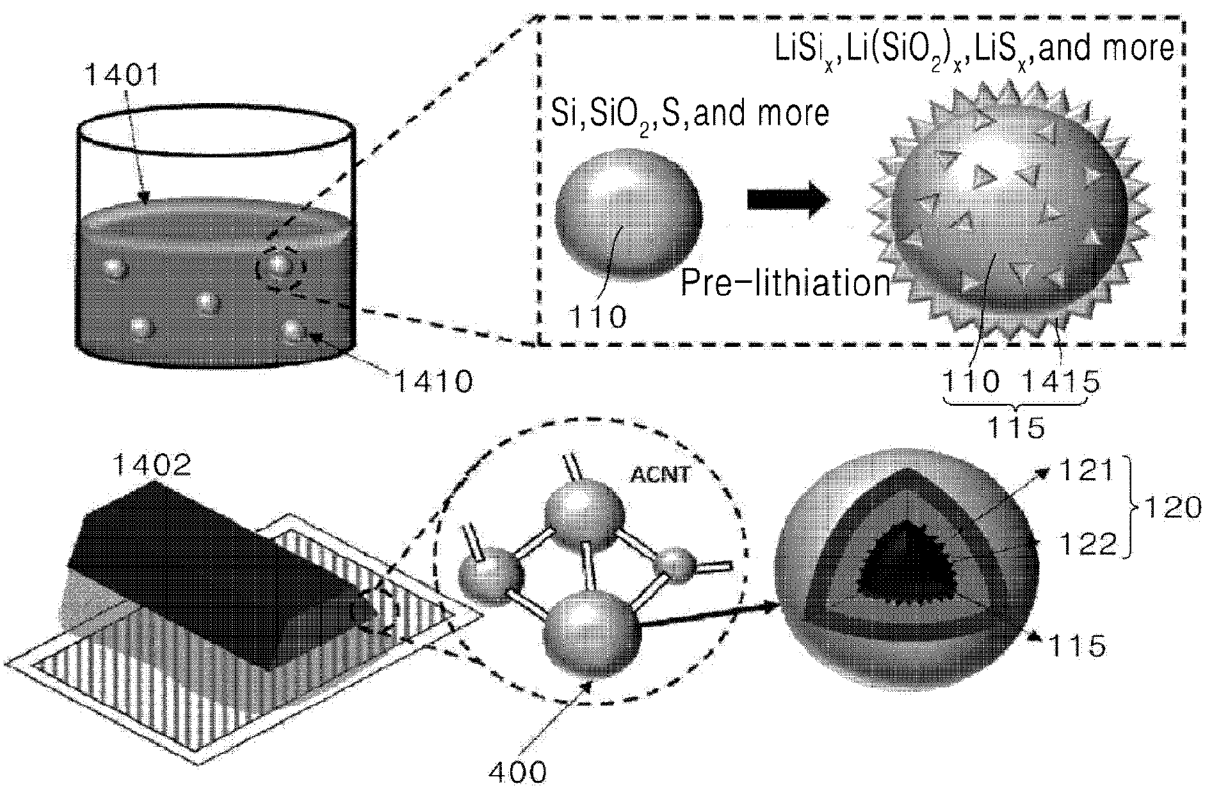
(a)Impedance(Nyquist diagram, 200 kHz ~ 100 mHz)

(b)Impedance(Nyquist diagram, 200 kHz ~ 100Hz)

[Fig. 13]

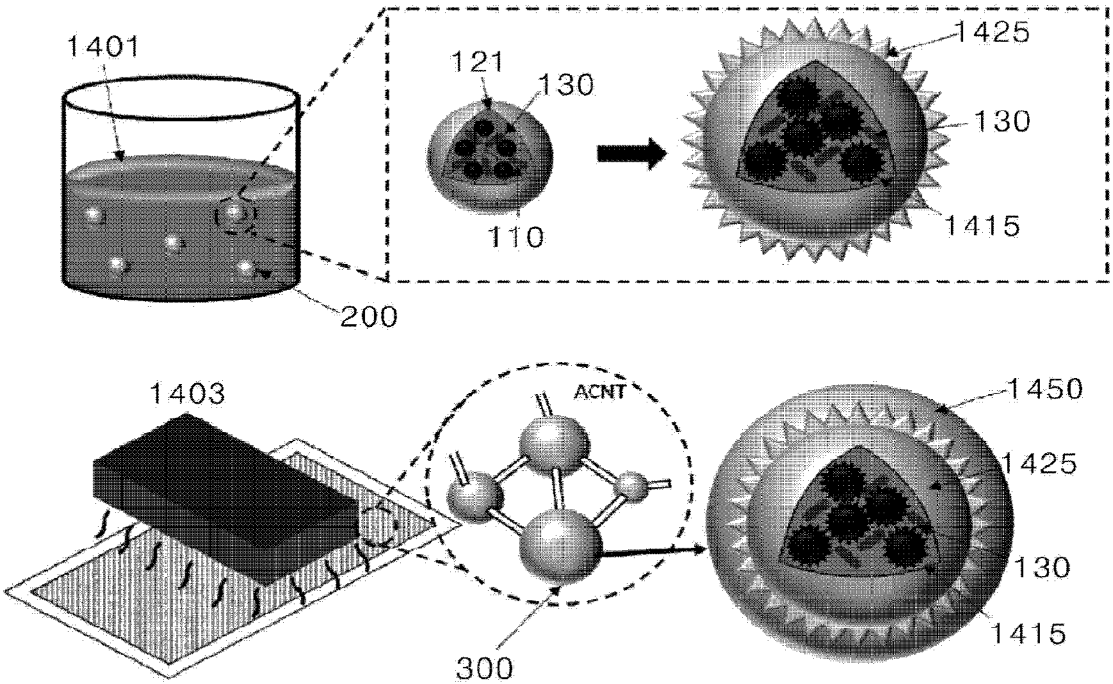


[Fig. 14]

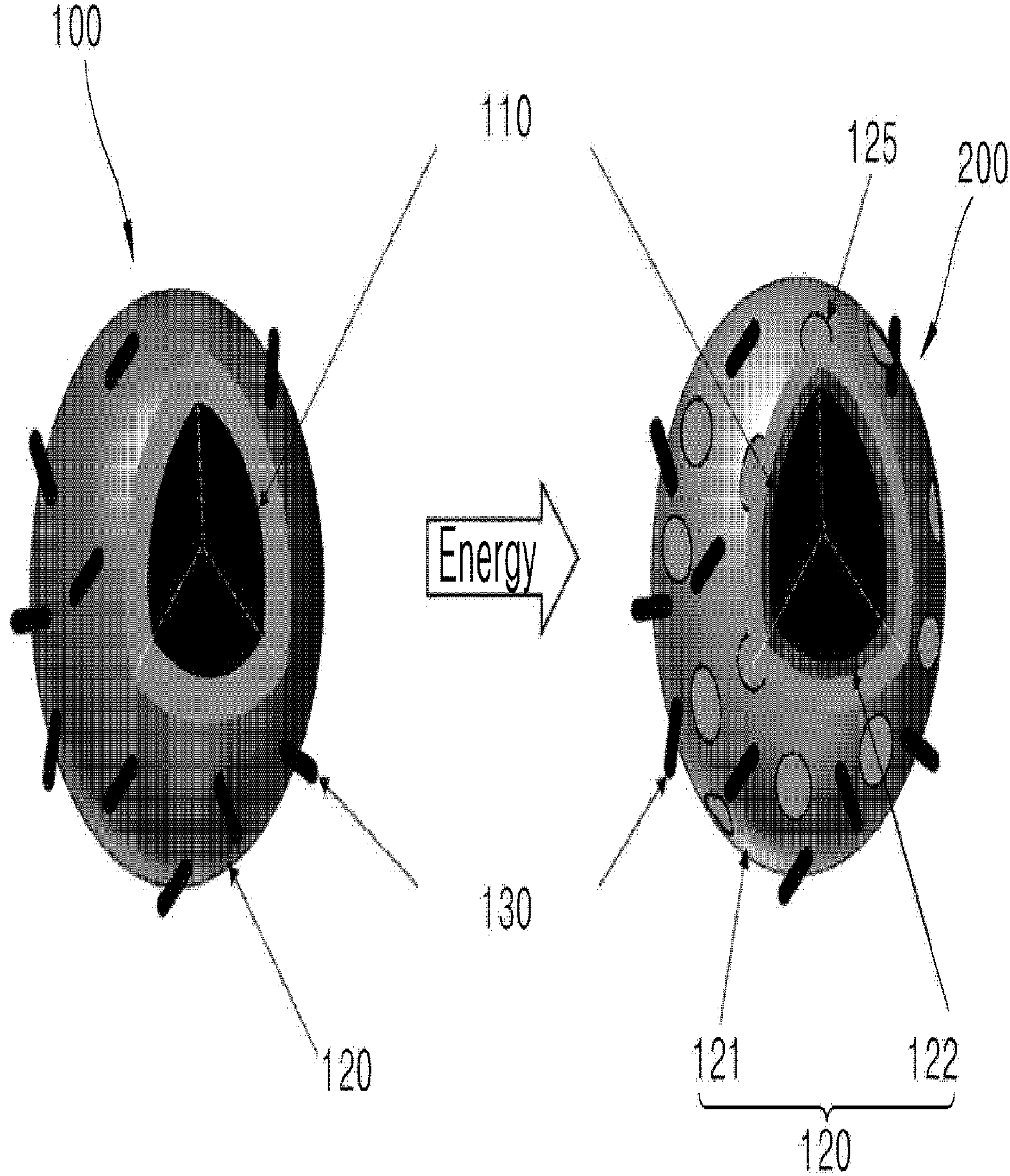


(a) Pre-lithiation before encapsulation and carbonization

[Fig. 15]



(b) Pre-lithiation after encapsulation and carbonization


100
110
125
200
Energy
130
120
121
122
120