Aichi / Nagoya Cluster【Environment-friendly manufacturing using Nano-Technology】

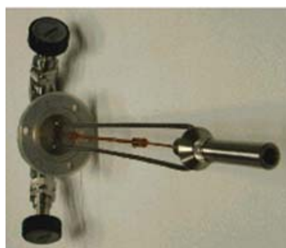
Nano Assembling System
Ultra compact light source for smart sensor (radical diagnostic sensor)
Novel carbon-nano-structure fabricated using plasma process with radical control

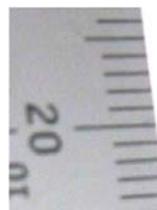
Department of Electrical Engineering & Computer Science
Nagoya University Professor Masaru Hori

Ultra compact light source for radical diagnostic sensor

Patent submitting

ϕ70mm light source (1999)


ϕ9mm compact light source (2002)



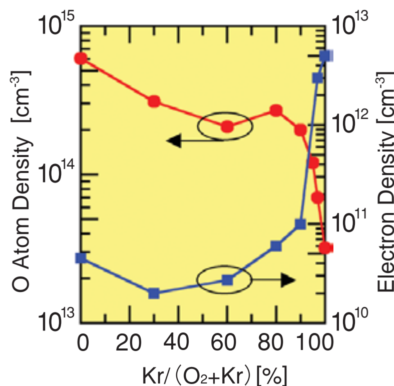
ϕ1mm Ultra compact light source (2003)

Feature

- Smart sensor for Autonomic Nano- Production Device
- Capable of measuring H, N, O radicals
- Unaffected for plasma measurement

Industrial applications

- Main sensor of Autonomic Nano- Production Device
- Measurements of absolute radical densities in various plasma process
- Clarifications of behaviors of radicals in plasma
  (Spatial density distribution, Clarification of generation and loss kinetics, Surface loss probability)



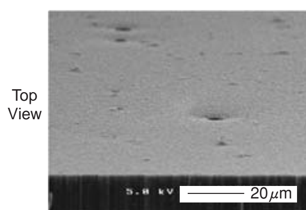
Example of measurement

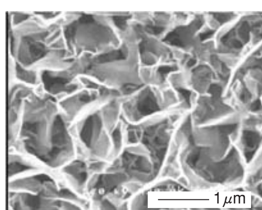
Behavior of O atom density in surface wave Kr/O_2 plasma for high quality and low-temperature process for oxidation of Si substrates (Pressure 90Pa, Power 1kW)

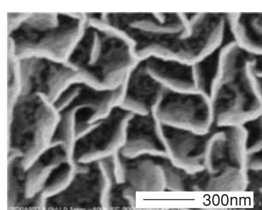
Novel carbon-nano-structure fabricated using plasma process with radical control

Patent submitting

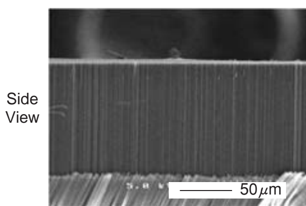
Top View



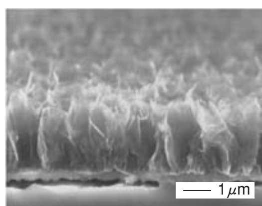




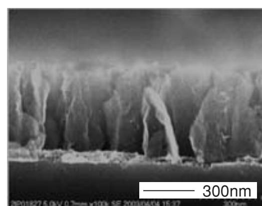
Side View



Carbon Nanotube
CNT



Carbon Nanoflake
CNF



Carbon Nanowall
CNW

Feature

Radical control enables:

- Fabrication of novel carbon nanostructure, called carbon nanowall (CNW)
- Fabrication of CNW and CNF without catalysis
- Development of large area fabrication system for multi-carbon nano structure

Industrial applications

- Field electron emitter
- Gas storage
- Fuel cell
- Catalyst carrier
- Nano-scale dies

The First Venture Business from Nagoya Nano-Technology Cluster of Innovative Production System
(Venture Business from Nagoya University)

~ Innovation of plasma process equipment on the basis of a nano-unit science ~

Aiming at realization of "Autonomic Nano-Production Device" using various absolute radical density measurement as a core.

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Description of study

By using radicals with high reactivity, the highly precise etching in the nano-scale and the fabrication of the functional thin films in the low temperature such as the room temperature are able to be realized.

In order to industrialize nano-technology as mass-production technology, we will develop the next generation manufacture device "Autonomic Nano-Production Device". The device controls a process autonomously with the ultra compact smart sensor(radical diagnostic sensor) to monitor the radicals and the control system feeding back the information from the smart sensor.

Autonomic Nano-Production Device

Autonomous Nano Process System

Atom molecular sensing system

Optimization of process condition

Autonomous optimal control

Electrode

Radical

Reaction space

Ultra-small radical diagnostic sensor

Multi channel sensor alley

Monitoring sensor
Substrate
Temperature
Film thickness
Film structure
Film composition

10nm

Nano process | Nano print | Particle cluster | Carbon nanostructure

Direction to "Autonomic Nano-Producing Device"

Radical monitoring system

Feature

The etch profile controlled in the nano-scale and the high etch rate in the etching process of the organic low-k film is realized by choosing the radical density ratio H/H+N.

Patent submitting

Etching Conditions
Vdc:-500V Total pressure:2Pa
Total flow rate:100sccm

Etch rate (nm/min): 0, 100, 200, 300
H/(H+N)Radical density ratio: 0.0, 0.2, 0.4, 0.6, 0.8, 1.0

N_2/H_2 =50/50; N_2/NH_3 =0/100; N_2/NH_3 =50/50; N_2/H_2 =0/100; N_2/H_2 =100/0

● N_2/H_2 Plasma
● N_2/NH_3 Plasma

Etch rate as a function of H radical density ratio

Side etching

Bowing

N_2/H_2 Plasma

SiO_2
Low-k film
SiO_2

H/(H+N) Radical density: 0.17, 0.81, 0.9

N_2/NH_3 Plasma

500nm

Etch profile as a function of H radical density ratio

Ultra high speed processing using microwave excited non-equilibrium atmospheric pressure plasma

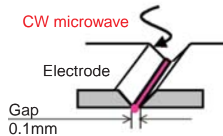
Patent submitting

Feature

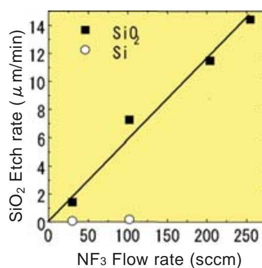
①Ultrahigh density of ions and radicals(active species)
②Increase of polymerization by collision between species
③High compatibility between plasma and liquid phase (Irradiation to living body)

A novel process of dry and wet etching with electrochemical reaction was realized.

・Microwave excited plasma



・Fabrication of carbon nanotube
(TEM image)



・Ultrahigh etching of SiO_2
Maximum etch rate: 14μm/min
SiO_2/Si ultrahigh selectivity: over 200

Radical and atom source (particle density is guaranteed)

Commercial production

In order to perform highly precise process, it is necessary to carry out the monitoring of absolute radical densities in plasma and control it by the information of the densities.

Radical and atom source with which particle density is guaranteed have been developed making full use of the radical density measurement technology and high density radical generation technology.

Feature

・Oxidization of the surface by O radicals
・Reduction of the surface by H radicals
・Nitrization by N radicals
・Cleaning

Radical and atom source

INQUIRY

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