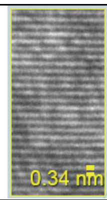
Stacked Graphene Platelet NanoFibers (SGNF) and Nano Chips



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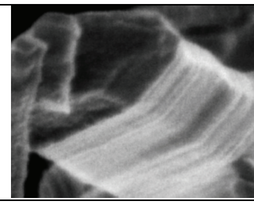

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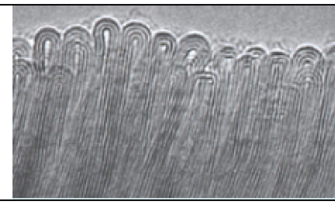

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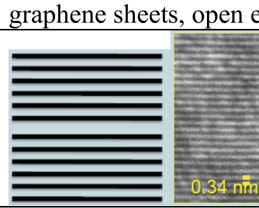
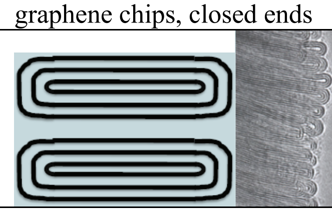
Strem Catalog No 06-0170 Carbon, stacked graphene platelet nanofibers (acid washed) SGNF
Strem Catalog No 06-0172 Carbon, platelet graphitic nanochips (SGNF heat treated)

Sold in collaboration with Catalyx Nanotech for research purposes only. Standard catalog sizes 1g, 5g, 25g. Larger quantities available. US Patents 6,995,115 and 7,001,586.

Stacked Graphene Platelet Nanofibers are grown via a patented process that decomposes carbon-containing gases in the presence of metal catalyst particles (Ni/MgO). The structure of the Stacked graphene platelet nano fibers consists of graphene sheets oriented perpendicular to the growth axis like a stack of cards, spaced 0.34nm apart. The fibers have a mean width of 40-50nm and are 100 - 10,000nm long! As-grown SGNF fibers contain about 2 wt% of metal catalyst particles which can be removed via an acid wash procedure.

Nano-Chips
High temperature heat treatment of the "as-grown" SGNF fibers, in a proprietary gas, removes the metal catalyst particles and seals the ends of the platelet graphene sheets to form stacked "nano-chips". These resemble rolled and flattened multi-walled carbon nanotubes containing 6-8 layers with inter-layer distances remaining at 0.34nm. These exhibit many unique properties including semiconducting.

Properties

Property	As-Produced SGNF	Heat Treated Nano Chips
Density (g/cm3)	0.3	0.3
Electrical Resistivity (µ W cm)	120	55
Stability in Air (oC)	700	700
Mean Width (nm)	40-50	40-50
Range of Length (nm)	100- 10,000	100- 10,000
Surface Area (m2)	120	120
	Stacked Graphene Nano Fibers graphene sheets, open ends	Nano Chips graphene chips, closed ends
	 0.34 nm	

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Applications

Catalysts for Fuel Cells : Carbon fiber may be a component of supported Platinum electrocatalysts for proton exchange menbrane fuel cells. The topic has been recently reviewed.[1] Platelet graphite nanofibers (SGNF) prepared by vapor deposition of hydrocarbons on nickel and other metals have been characterized by XRD, electron microscopy, and adsorption methods, and used in manufacture of active platinum containing cathode composites for methanol and hydrogen type fuel cells. Raw fiber may be treated with acid to remove metal deposition catalyst, treated with aqueous platinum salts, reduced at elevated temperature, oxidized to stabilize dispersion, and combined as composites with, for example, a preformed graphite sheet or cloth to act as a current collector. Such assemblies are often compared with similar assembles made from the standard 30% platinum loaded, graphitic, pyrolysis process carbon black, with the object of achieving similar performance with lower loadings of platinum.

In various studies, test membrane and electrode assemblies exhibited superior performance as follows:

1) Higher current efficiency is achieved at lower platinum loading.[2 3]
2) High activity is achieved at temperatures well below 80 °C.
3) Excellent dispersion of platinum is achieved.[2 4]
4) Cyclic voltametry studies predict Pt becomes more resistant to poisoning by carbon monoxide.[3]
5) Low mass transport losses are found at high current density.[4]

NEC Corporation has developed miniature fuels cell catalyzed by nano-carbon supported Pt.

Lithium ion rechargeable batteries:
SGNF can easily be intercalated by Lithium. During this process, species are trapped between the graphene layers. Preliminary experiments indicated that the performance of vapor grown (fishbone layered, iron catalyzed) graphite nanofiber was superior to that of Li/graphite samples, both during high charging and discharging anode cycle rates. The lithium ion insertion and deinsertion capacities were estimated to be superior to comparative carbon fibers not produced by a vapor deposition process.[5] In a detailed investigation a similar nanofiber was formed into an electrode with binders on a copper foil substrate and combined with a lithium electrode to make a cell and cycle tested. The graphite nanofiber was slightly superior in de-intercalation capacity to carbon black although both were inferior to graphite.[6] A very recent study found performance was binder dependent with nanofiber outperforming graphite under some conditions.[7]

Separations:
There is potential to use SGNF to separate very miscible substances, such as soluble organic contaminants from water. The reactive sites on these materials includes the graphene platelet edges, hence potentially, the adsorption is due to Pi-Bonds, not just Van Der Waal's forces. Thus, the use of highly ordered SGNF carbon nanofibers for the removal of volatile organic carbon pollutants, such as phenol and chlorophenol, from water has been investigated. Carbon nanofibers of varying overall dimension and lattice orientation were synthesized through the decomposition of ethylene over supported and unsupported nickel catalysts. Activated carbon and graphite samples were used for comparison. The use of catalytically generated highly ordered carbon nanofibers proved to be a viable option for the uptake of phenolic compds. Phenolic adsorption was less than that associated with the model activated carbon and greater than that recorded for model graphite.[8]
The outcome of intense research in recent years on use of vapor deposited graphite nanofibers to construct hydrogen storage devices has generally not yet confirmed what were thought to be initially promising feasibility studies.[9 10]

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Catalysts:

Growing attention has been paid to carbon nanofibers in heterogeneous catalysis due to their unique graphitic platelet orientation, high surface area, and chemical inertness. Introducing oxygen-containing groups by oxidation treatment increases the hydrophilicity of the nanofibers and improves wetting by metal precursor solution. The graphitic platelet orientation of carbon nanofibers influences the number of oxygen-containing groups and there exists a linear correlation between the amount of oxygen-containing groups and the relative loading of, for example, palladium.[11] Such oxidized SGNF show promise as carbon nanofiber supported cobalt Fischer–Tropsch catalysts. In use, gas re-reduction is required to regenerate active catalyst. Nickel treated SGNF has been characterized by TEM and evaluated as a hydrogenation catalyst. It is evident that when nickel was supported on graphite nanofibers, the catalytic activity for hydrogenation of the olefin at 80 °C was appreciably higher than that found when the metal was supported on either active carbon or γ-alumina.[12] Similarly, palladium and ruthenium has been deposited on SGNF to form hydrogenation catalysts.

Supercapacitors:

Supercapacitors, ultracapacitors or electrochemical double- layer capacitors (EDLCs) are terms used for the same type of electric component of capacitance value reaching thousands of Farads. At such capacitance value, supercapacitors become an alternative means of electrical energy storage. Supercapacitors' comparison with batteries as the usual means of electrical energy storage reveals advantages and disadvantages. One major disadvantage of supercapacitors is significantly lower specific stored energy [2]. Most of available commercial products have a specific energy below 10 Wh/kg, values as high as 150Wh/kg is possible for lithium ion batteries. However supercapacitors can be rapidly charged and discharged and have a very high cycle life. For example, one can buy a supercapacitor based cordless screwdriver that recharges in 90 seconds. At this time, the manufacturing technology of commercial supercapacitors is based on carbon material for their electrodes. A combination of high surface area, pores in the 2-50nm range, and wettability are desired. Carbon nanotubes can show higher specific capacitance than activated carbon, but are very expensive.[13] Recently, SGNF and certain related carbon nanofibers have been shown to outperform carbon nanotubes.[14] [15]

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