Application Note

High precision mixtures for carbon nanotubes (CNT) development

MCQ Gas Blender 100 Series CVD-related Application

Introduction

Nanotechnology field research represents today one of the ultimate science frontier, as astonishing promising as incredible hard to achieve. Nano-sized materials application offers new exciting possibilities for revolutionary goal achievements and for further development in almost every scientific branch. What could only be imagined a few years ago may now become real. In this new wave that's getting the future one step closer to modern science, Carbon NanoTubes (CNTs) and related wide set of possible applications represent one of the more complex, studied and promising system.

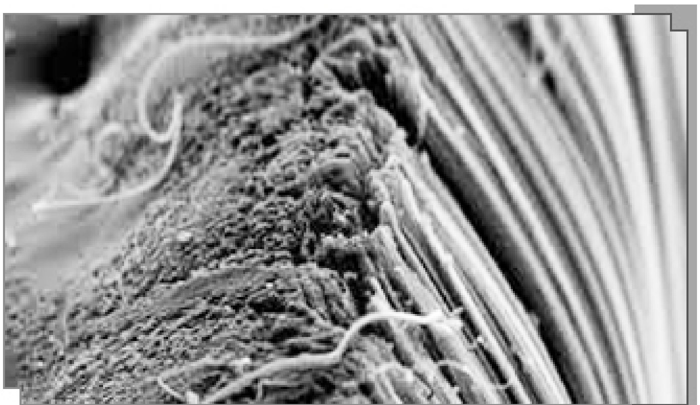
Applications

Carbon nanotubes are allotropes of carbon, organized in a specific form called graphene, arranged in a cylindrical nanostructure. The CNTs structure, related to the peculiar atoms arrangement in space, gives CNTs the physical and chemical unique properties on which the great scientific interest grown around in the last decade. The simplest CNTs space configuration is the single-walled nanotube (SWNT) but structures made of different concentric nanotubes nested within one another, called multi-walled nanotubes (MWNT) can also be synthesized. These MWNT are especially interesting due to their telescoping property (inner nanotubes may slide, almost without friction, within its outer shell) that makes them a perfect example of molecular machine nanotechnology. Their structure makes CNTs the strongest and stiffest material yet discovered in terms of tensile strength and elastic modulus, while, due to their hollow structure and high aspect ratio, they tend to undergo buckling when, for example, placed under bending stress. The CNTs graphene structure also strongly affects its electrical properties, making them moderate semi-conductors. Electrochemical properties for supercapacitor applications are also well known. However, what makes CNTs so extraordinary special its their dependence of nanotubes size and aspect-ratio, changing what it's possible to manage and consequently tune CNTs features to desired values. CNTs can be done at different lengths, angles and curvatures resulting in an unparalleled tunable and versatile material.

Process optimization

CTNs are currently synthesized using different deposition techniques, particularly Plasma Enhanced Chemical Vapor Deposition (PECVD) and Hot Filament Chemical Vapor Deposition (HFCVD). Both have strengths and weaknesses and there's still a debate on which is best for CNTs applications [1,2]. However both techniques follow the same procedure steps for the nanotubes synthesis:

- **Substrate preparation**: metal catalyst nanoparticles (usually Ni, Co, Fe) are placed like a thin layer on the substrate in order to act as nuclei for the CNTs grown.



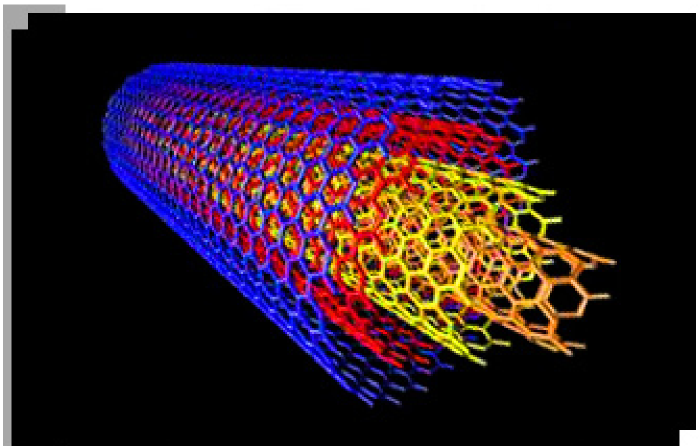
High magnification carbon nanotubes micrograph

- **Substrate annealing:** the substrate is heated to approximately 700°C to activate the grown reaction.
- **Gas Blending:** a process gas (ammonia, nitrogen, hydrogen) and a carbon-source gas (acetylene, ethylene, ethanol or methane) are mixed and flown into the reactor chamber.
- **CNT grown:** the hydrocarbon gas mixture is thermally activated (fragmented) by the catalyst nanoparticles on which the so formed carbon fragments give rise to the nanotubes.

Size, structure and quality of CNTs can be tuned and adjusted due their strong dependence on parameters choice and process optimization. CNTs changes and modifications related to working pressure [3,4], deposition temperature [5] and catalyst nanoparticles choice [6-8] has being well studied but at the same time gas mixture composition and variations represent another important branch of research. Works published during the last 10 years have shown how crucial the precursors choice [9,10], concentration [11] and even temperature [12] can be at affecting the final result.

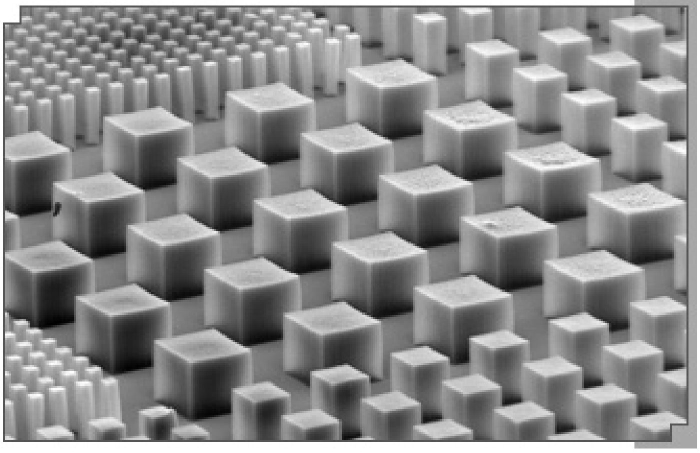
High Precision Gas Mixtures

For these very reasons, an instrument capable of managing your desired gas mixture (allowing instant composition changes, if needed) with high precision and reliability is definitely required. The MCQ Gas Blender 100 Series is an excellent choice for those who want to undertake studies regarding CNTs properties and related gas phase dependence. The Gas Blender 100 is a simple, intuitive and at the same time a highly professional instrument, designed to work with 3 components non-aggressive gas mixtures.



Multi Walled Nanotube (MWNT) scheme

Self-assembly CNTs structure grown by CVD



The Gas Blender 100 Series offers a high accaccuracy (1% of setpoint), high repeatability (0,16% of reading value) and the fastest response time for setpoint value changes on the market (50 ms). The MCQ provide its instruments calibrated on customer request but in case of need it's possible to work with different gas settings configurations throughout the use of conversion factor related to each gas media. Along with the instrument, the MCQ Gas Mixer Manager software for the gas mixtures management, is also provided. Compatible with any Windows-operating desktop and laptop personal computer, the Gas Mixer Manager is a complete and useful tool created to give the user immediate access to all the functions of the Gas Blender 100, making it possible instantly create and manage the desired dynamic gas mixtures.

References

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