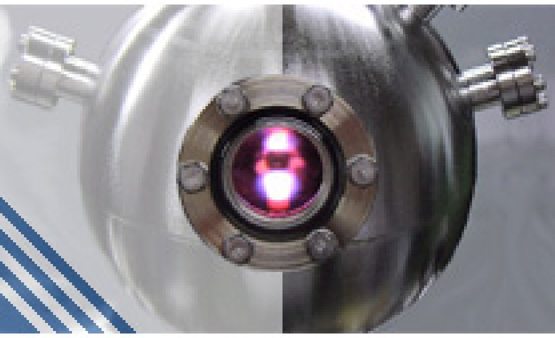
Application Note

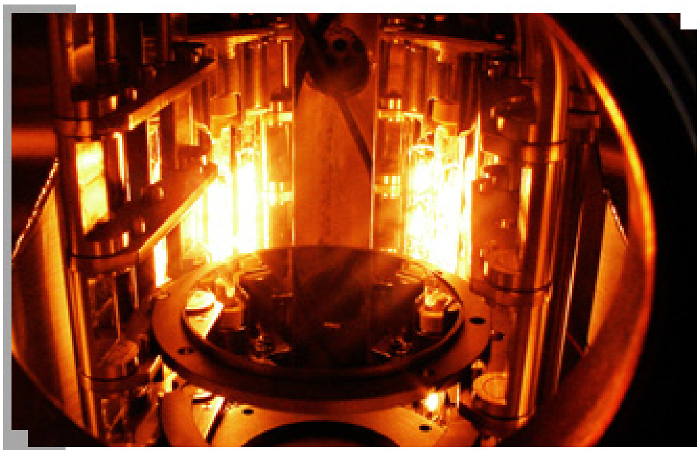


MCQ Gas Blender 100 Series Application

Dynamic mixtures applied on Deposition techniques

Introduction

Over the last 20 years, Chemical Vapor Deposition (CVD) processes has taken a key-role in a wide range of technological advanced manufacturing. Today the industrial processes for anti-wear cutting tools coating and microprocessor production share the same deposition techniques, proving a constant self-developing process that is extremely useful and versatile. CVD is a generic name for a huge family of processes that involves the use of gaseous precursors in order to produce high-purity and high performance solid materials. The gaseous phase usually is thermally activated inside the CVD chamber by an adequate heat source to produce a chemical reaction that leads to the desired products formation, and subsequently to the products deposition on the target-substrate. CVD involves the use of hot filaments to activate reactions (HFCVD) and it also requires extremely low working pressures. Different type of heat sources (e.g. plasma, laser) have proved to be useful and now plasma-enhanced deposition (PECVD) and Laser CVD (LCVD) are of common use. Pressure is not a problem anymore since, in some applications, the deposition can be performed in atmospheric pressure (APCVD). The deposition results strongly depend on process parameters and hardware configuration settings. This strong dependence requires a fine control and a fine regulation for each step of this technique. A particularly precise care on the gas phase composed by the reactants must be exercised. An instrument capable of producing gas mixtures with high precision and designed to be versatile and easily manageable is thus required for this kind of applications. The MCQ Instruments offers it all with its Gas Blender 100 Series, a product specifically built for 3 components gas mixture.



A CVD chamber during the deposition process

CVD applications

The versatility of CVD technique(s) is proven by its use in a wide array of different research and application fields. The experimentation fields can be summarized in four main categories: thin and thick film applications, powder treatments (fluidized bed CVD) and carbon nanotubes research.

- Thin films

This term refers to nanometers in coatings up to a few micrometers thickness, made to improve the specific performance of a base material. The synthetic diamond (CVD diamond), due to its unique chemical and physical properties, is a perfect example of thin film application. The hardness and chemical inertness of micro- and nano-crystal diamond films are generally used to increase the wear resistance of metallic/ceramic components [1,2] while single crystal diamonds take a crucial role in the making of cutting tools [3,4]. In the last 20 years CVD diamond has proved itself to be a versatile material studied nowadays for electronic applications in the radiotherapy [5] and in the spintronics field [6]. On the other hand increasing the anti-wear resistance can be achieved throughout ceramic coatings based on Ti, Cr and Zr [7,8]. Over recent years such coatings have also become an interesting research field for their antibacterial applications [9].

• Thick films

This term refers to micrometers in coatings up to millimeters in thickness, made to improve specific performance of base materials or to create free standing items with desired features. CVD diamond takes again an important role in such coatings, has been used to increase cutting tools quality level [10] as a coating or used for electrical application as free standing material [11]. Ceramic coatings are also used for these thick films as excellent thermal barriers [12]. However, despite the wide use of diamond and ceramic coatings, the experimentation on silicon is today the most studied topic in thick films research field. Solar cells production [13] and microprocessors manufacturing [14] both are the main fields on which CVD research and optimization efforts are focused.

• Powder treatment

Treatment of powders is another interesting CVD application combining the chemical process (taking place during deposition) with mechanical effect produced by the Fluidized Bed technique. Fluidized Bed Chemical Vapor Deposition (FBCVD) is one of the most efficient techniques to functionalize, deposit on and coat each individual particle of a powder from different gaseous species. Activated and/or coated powders are used for anti-wear applications [15], catalyst synthesis [16], carbon nanotubes synthesis [17] and photoreactor designs [18].

A cutting tool coating with Chromium Nitride

A thick films technology application: Solar Panel

• Carbon nanotubes

This is one of the newest and promising CVD applications. The nanotechnologies represent the future and the last frontier of worldwide research. In this context carbon nanotubes take a key role. Made through HFCVD or PECVD, carbon nanotubes great interest is due to their peculiar features making them a unique material adaptable for many applications. Carbon nanotubes are the strongest material in term of tensile strength and elastic modulus, which makes them suitable for many mechanical applications [19] and advanced textile production [20]. Their peculiar shape makes them potentially useful for air filter creation [21] or H2 storage purposes [22] and their semiconductor nature may turns to be effective for electronics applications [23,24].

CVD Apparatus

Although each deposition technique makes use a different hardware configuration, all the depositions share the same reaction principle so the same basic features can be found in each apparatus. A common CVD apparatus consists of several basic components:

- **CVD reactor**, the chamber within which deposition takes place.
- **Energy source**, needed to provide the energy/heat required to get the precursors in the gas phase to react/decompose.
- **Vacuum system**, usually a pump of a system of pumps required to completely clean the chamber from all undesired gaseous species in the initial stage of deposition process.

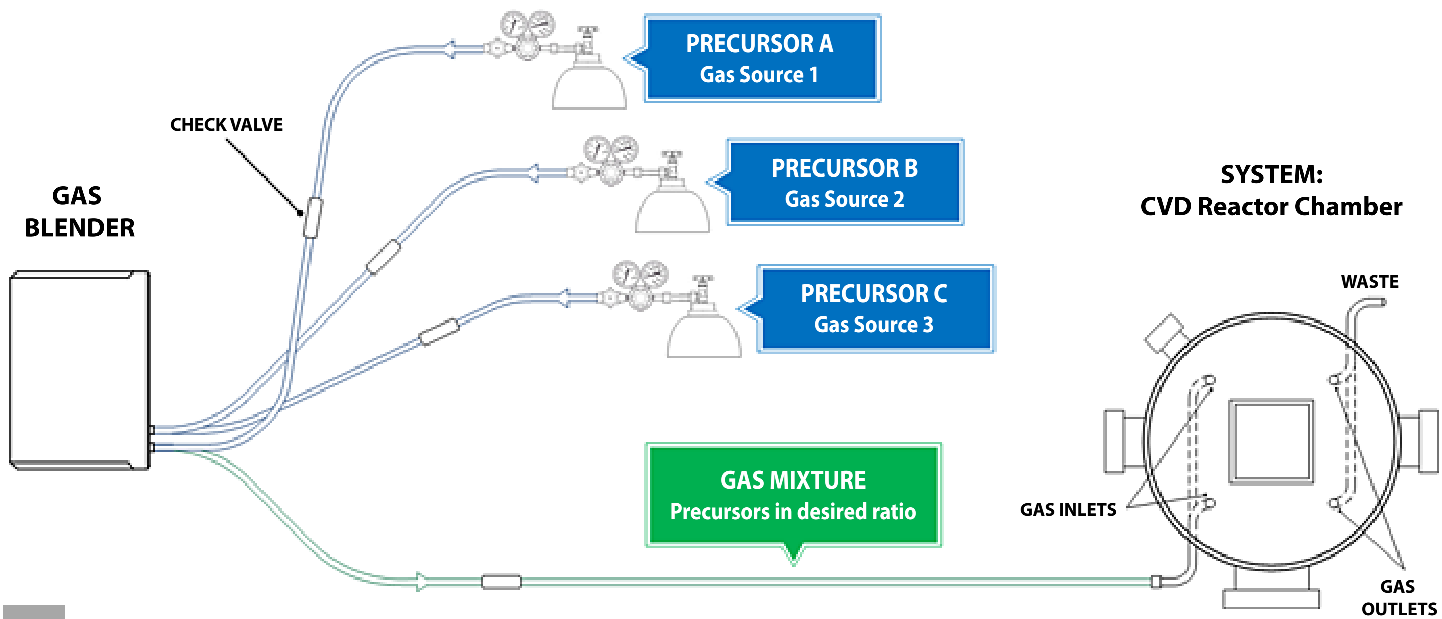
- **Exhaust system**, implemented for removal of volatile by-products from the reaction chamber.
- **Substrate loading mechanism**, an optional feature created for introducing and removing substrates in the chamber without stopping the deposition process.
- **Gas delivery system**, used for blending the mixture and supplying it to the reactor chamber.
- **Process control equipment**, the wide array of controls installed to monitor process parameters such as pressure, temperature, time and gas mixture properties.

Gas Blending: MCQ Solution

The gas blending solution commonly used for deposition purposes consists in 2 or more (depending upon the nature of the mixture the experimentation requires) single channel mass flow controllers, which work independently from each other. In order to blend the mixture and to manage the mixture settings (i.e. the relative amount of precursors in the gaseous phase) an external control unit, connected with all mass flow controllers, is thus required. Such a system suffers of two major practical issues: it demands a considerable amount of laboratory space and the mixture parameters changes are often laborious, making it almost impossible to work with deposition conditions that requires dynamic mixture adjustments. The MCQ faces those problems providing a new solution for gas mixing with the MCQ Gas Blender 100 Series, an instrument especially created for advance CVD applications. The Gas Blender 100 Series is a high precision 3 channels mixing device that work with non-aggressive gas media. The instrument, designed following the “Lab in a box” principle, offers the advantages of 3 single-channel mass flow controllers all in a compact box, easily to handle and to install wherever it’s needed. The Gas Blender 100 Series requires no external control unit, for all the mixture parameters and other gas settings can be managed by the user with the MCQ Gas Mixer Manager, the software specifically created to access all the Gas Blender features. Create mixtures and adjust them dynamically, with the possibility to change gas phase composition anytime and instantly, has never been easier. The software only requires a desktop or laptop computers compatible with any Windows operative systems starting from Windows XP.

● Hardware Configuration

An example of MCQ Gas Blender 100 Series hardware configuration is represented in the scheme below. The gas in use must be dry, non-aggressive gases. The instrument works with pure or mixtures gas media (the example shows pure gases for simplicity). The gas cylinders are connected to the instrument through 6 mm diameter tubes and a check valve is installed along each line as backflow prevention device. Each gas is connected and controlled by a dedicated channel of the Gas Blender 100. Another 6 mm tube finally connects the instrument to the working system (a generic CVD reactor chamber) in which the experiment takes place.



MCQ Gas Blender hardware configuration

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