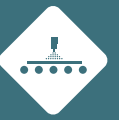


# Diamond Deposition HFCVD



Application note A010-ST03-1216C



**Diamond has got a unique wear resistance, therefore diamond coatings are often used to improve the performance of cutting tools and wear parts. In order to obtain diamond coatings over adequate substrates, it is necessary to combine the suitable amounts of the right gas precursors and heat them for reactions to occur.**

There are several methods for the excitation of the gas phase: microwave plasma, flame jet or even laser. However, the present application note concerns the hot-filament vapour deposition technique (HFCVD).

Typically in this method a dilute mixture of carbon containing gas such as methane in hydrogen is thermally activated at sub atmospheric pressures by a hot filament. The gas mixture and flow must be cautiously controlled; hence the use of high performance massflow controllers is imperative.

- ◆ Wear resistant cutting tools
- ◆ Corrosion resistant tools
- ◆ Anti-reflective coatings



*Hot filament Chemical Vapour Deposition reactor for diamond deposition*

## Application requirements

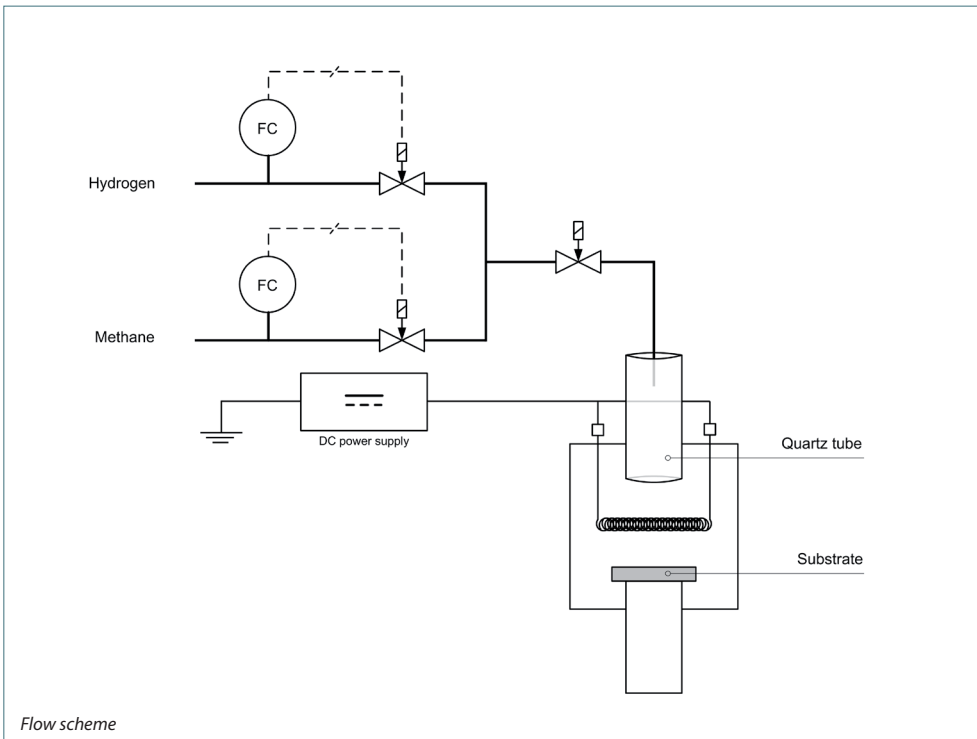
It is of utmost importance that the mass flow controllers used can guarantee both the proper total amounts of gases and the repeatability of the process; otherwise the uniformity and overall quality of the attained thin films will be compromised.

The instruments must be extremely reliable and possess analogue or digital communication, because careful control and monitoring are essential due to safety issues related to the ignitable and explosive nature of the gases involved in the process.

Important topics

- ◆ Excellent repeatability
- ◆ High accuracy
- ◆ Fast response time
- ◆ Stability

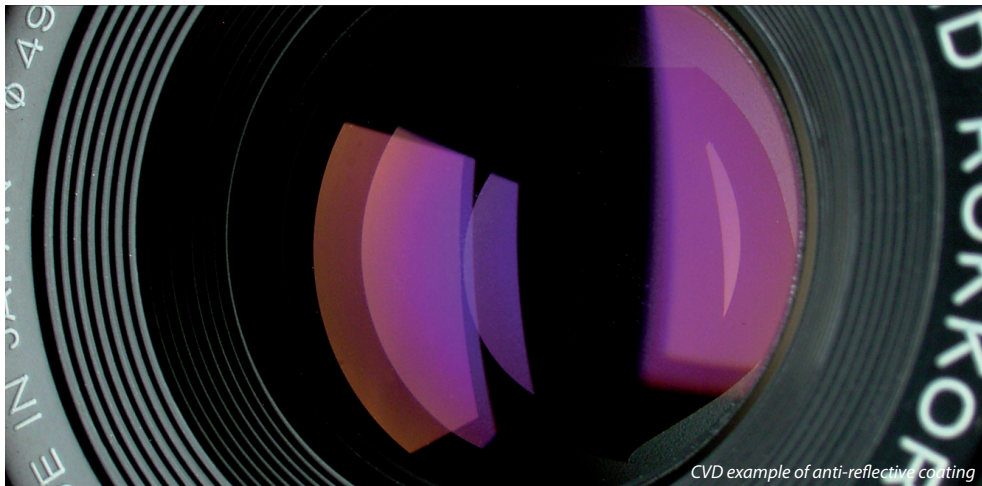
## Process solution



One of the most versatile methods for the production of diamond films is the hot-filament vapour deposition technique (HFCVD) where the gas mixture is heated by being passed along thin W or Ta wires ( $\varnothing 100$  to  $300 \mu\text{m}$ ) that are heated up to  $2400^\circ\text{C}$ . Usually only two gases are needed:  $\text{H}_2$  and  $\text{CH}_4$ , the methane being diluted at 1 to 2 vol% in the hydrogen. The total pressure inside these cold-wall HFCVD reactors can vary typically between 20 mbar and 200 mbar, the total flow depending on the size and geometry of the reactor chamber.

A recent type of diamond coatings is termed nanocrystalline diamond (NCD), in opposition to the microcrystalline diamond films (MCD). NCD is characterized by a nanometric crystallite size (1 nm to 50 nm) and an extremely smooth surface that retains most of the hardness of MCD and has got improved wear and friction behaviour relatively to MCD. These coatings generally need the addition of a third, inert gas, that contributes to the formation of NCD by enhancing re-nucleation processes during growth and by changing the thermal load of the gases inside the chamber, also affecting the substrate heating. This system is more complex than the MCD one and further care is needed in the control and monitoring of the feed gases. A further modification of such reactors consists in doping the diamond coatings with Boron (MCD and NCD) during growth in order to ... ►

... make them electrically conductive. For this liquid precursor containing Boron (B) species is generally used and a gas is bubbled through it, carrying the B containing vapour to the hot filaments and to the diamond coatings. The doping level is adjusted by selecting the right concentration of B in the precursor and by adjusting the gas flow through the precursor. The task becomes increasingly difficult when doing NCD since three gases are already at play. The role of the MFCs is insurmountable in this application or any other involving CVD processes for diamond growth from gas phases.



## Recommended products

|   |  |  |
|---|--|--|
|    | <p><b>EL-FLOW Select</b></p> <p>The instruments are truly unique in their capability to measure and control flow ranges between 0...1 ml<sub>n</sub>/min and 0...1670 l<sub>n</sub>/min. Its proportional, electro-magnetic control valve allows extremely fast and smooth control characteristics.</p>  | <ul style="list-style-type: none"> <li>◆ Fast response, excellent repeatability</li> <li>◆ High accuracy</li> <li>◆ Virtually pressure and temperature independent</li> <li>◆ Also available with IP65 housing</li> <li>◆ Stability</li> <li>◆ Maintainability</li> <li>◆ Quality</li> </ul>   |
|   | <p><b>LOW-ΔP-FLOW controller</b></p> <p>These instruments possess larger flow channels which minimises the risk of clogging and facilitates the cleaning and purging. All fluid wetted parts are of electro-polished stainless steel. Based on this concept, mass flow capacities between 0...10 ml<sub>n</sub>/min and 0...1000 m<sup>3</sup>/h can be measured. At a flow up to 2 l<sub>n</sub>/min a pressure drop of &lt;1 mbar is required.</p> | <ul style="list-style-type: none"> <li>◆ Very low pressure drop</li> <li>◆ Suitable for corrosive gases</li> <li>◆ Wetted parts; electropolished stainless steel</li> <li>◆ Also available with IP65 housing</li> <li>◆ Stability</li> <li>◆ Maintainability</li> </ul>  |
|  | <p><b>IN-FLOW Industrial style IP65</b></p> <p>IN-FLOW Series Mass Flow Meters/Controllers are thermal mass flow meters of modular construction with a 'industrial style' pc-board housing. Control valves can either be integrally or separately mounted, to measure and control gas flows from: lowest range 0,2...10 ml<sub>n</sub>/min up to highest range 220...11000 m<sup>3</sup>/h</p>   | <ul style="list-style-type: none"> <li>◆ High accuracy (typical 0.8% of Rd plus 0.2% of FS)</li> <li>◆ Pressure ratings up to 700 bar (higher on request)</li> <li>◆ Electro-chemical polished of all surfaces</li> <li>◆ Rugged, weatherproof housing (IP65)</li> <li>◆ No moving parts</li> <li>◆ Analog or digital communication (RS232 or fieldbus interface)</li> </ul> |
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## Contact information



Diamond  
Deposition HFCVD  
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ST: Surface Treatment  
03: Tooling Production

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