# A010-FLOW CONTROL FOR HFCVD

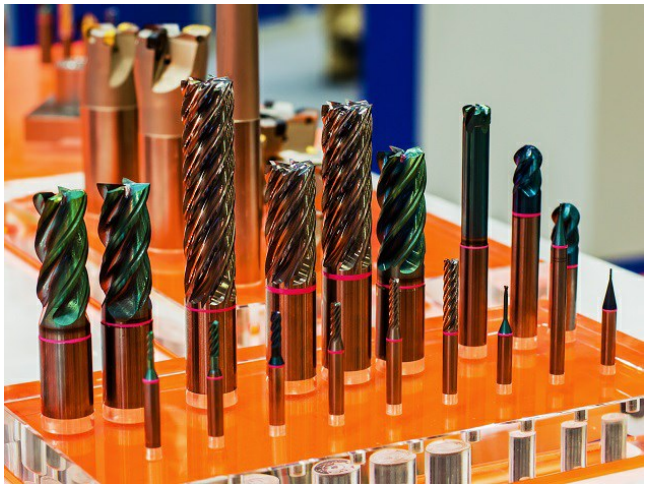
APPLICATION NOTE

# FLOW CONTROL & MONITORING FOR DIAMOND COATING

## using Hot Filament Chemical Vapour Deposition - HFCVD

**Diamond has got a unique wear resistance, which makes it a perfect coating for cutting tools. There are several techniques used in diamond coating processes, one of them is Hot Filament Chemical Vapour Deposition (HFCVD).**

This technique uses a dilute mixture of carbon containing gas. The gas, such as methane in hydrogen, is thermally activated at sub atmospheric pressures by a hot filament. The gas mixture and gas flow must be **cautiously controlled**; flow controllers are used to guarantee the proper **amount of gas** and the **repeatability** of the process.



## 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.

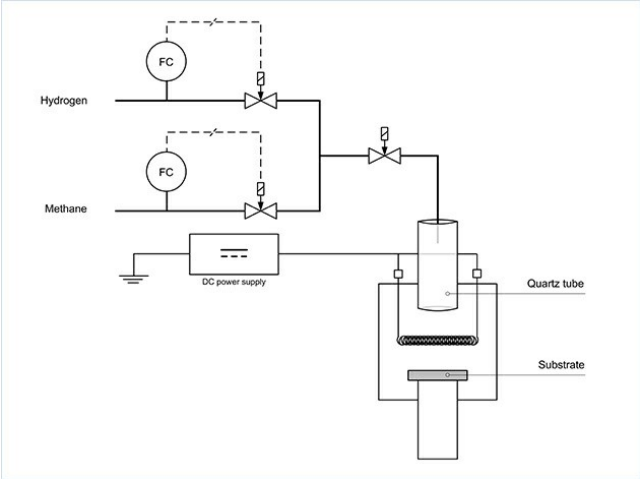
## Important topics

- 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 (⌀100 to 300 µm) that are heated up to 2400ºC.
Usually only two gases are needed: $H_2$ and $CH_4$, 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 an 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.



Flow scheme

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 Boron containing vapour to the hot filaments and to the diamond coatings. The doping level is adjusted by selecting the right concentration of Boron 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. Mass flow controllers, like EL-FLOW Select, LOW-dP-FLOW or IN-FLOW series, play a key role in applications involving CVD processes.

## Recommended Products


### EL-FLOW SELECT F-201CV

Min. flow 0,16…8 mln/min
Max. flow 0,5…25 ln/min
Pressure rating 64 bar
Compact design
High accuracy and repeatability


### LOW-ΔP-FLOW F-202EV

Min. flow 0,17…8,5 ln/min
Max. flow 1…50 ln/min
Pressure rating up to 10 bar
Low ΔP, easy to purge
Compact design


### IN-FLOW F-201CI

Min. flow 0,16…8 mln/min
Max. flow 0,5…25 ln/min
Pressure rating 64 bar
Compact IP65 design
High accuracy and repeatability

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