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The Ways to Synthesize Amorphous or Nanocrystalline material from a Vapor Phase

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Abstract – This paper deals with Chemical Vapor Deposition (CVD) and ALD (Atomic Layer Deposition) processes which lead to materials elaborated from a gaseous phase. These processes constitute an important technology in many applications fields such as microelectronics, energy, protective coating industry …. Once the target material is identified, to achieve specific film properties, efforts should be focused on the obtention of a particular film microstucture. The microstructure of the deposited layer is determined by the roles played by the growth phenomena and as a consequence, is strongly dependent on the choice of the process parameters (nature of chemical precursor, nature and structure of the substrate on which the material has to be deposited, temperature, total pressure, nature and partial pressures of the gaseous species).

Depending on the application, the preliminary questions to be answered before any experimental work on film deposition from a vapor phase are:
- Which are the best material nature, composition, thickness and microstructure that meet the requirements for the given application?
- Once the material nature defined, which process is the most adapted, and from which precursors?

When looking forward amorphous or nanocrystalline microstructure, it is obvious that synthesis of amorphous material using Chemical Vapor Deposition is more difficult than using non-equilibrium thin-film techniques (e.g. Physical Vapor Deposition) that can yield amorphous phases from a variety of systems. That requires systems with the strongest thermodynamic propensity for amorphization. The thermodynamic prerequisites for amorphous material stability have been generally defined [1]. A certain degree of directional bonding (in the limits, covalency) is needed. It is expected that ceramics obtained by CVD tend to be amorphous while metal deposit tends to be more crystalline.

However, for a given material, the deposited film microstructure can be tailored from the deposition operating parameters. General trends on the correlation between gas phase supersaturation (which depends on temperature, pressure and partial pressures of the gaseous species) and morphology of CVD films have already been reported (figure 1) [2,3].

Examples from ALD and CVD deposition processes developped within our laboratory and from the litterature will be described to illustrate the effect of deposition parameters on the films physico-chemical properties (morphology, structure, …) [4-8]. Comparison with results obtained with PVD (Physical Vapor Deposition) processes will be given.

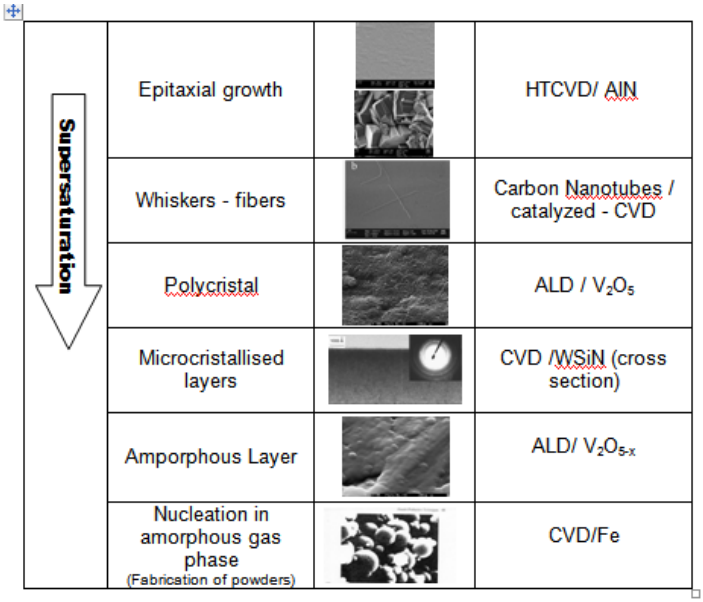

Figure 1: Evolution of films morphology vs. gas phase supersaturation. Examples of obtained films microstructure [4-8]

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