1. INTRODUCTION

Patented in the early 70s [1], the Pyrosol® process belongs to the reactive chemical spraying process family. It was developed for the production of Indium Tin Oxide (ITO) coated glass for use in liquid crystal displays. The Pyrosol® process, which may be considered as a low temperature CVD process, is a method of choice for the deposition of thin oxide films for various applications concerning electrical and optical properties, corrosion protection, coloration, etc.

2. PRINCIPLE

The Pyrosol® process is based on the PYROlysis of an aeroSOL. The aerosol is generated by the ultrasonic spraying of a solution containing the source compound. It is then conveyed by a carrier gas close to the heated substrate to be coated and it is decomposed by pyrolysis as follows: evaporation of the solution leading to a precipitate of the source compound, sublimation of the source compound, heterogeneous solid/gas reaction between the substrate surface and the source compound vapor in a CVD like reaction. The process is performed under atmospheric pressure.

2.1 Aerosol production

The focusing of an intense ultrasonic beam close to the surface of a liquid results in the formation of a geyser and an aerosol (figure 1). The properties of the aerosol depend on the characteristics of the liquid and the frequency and the intensity of the ultrasonic beam. Kelvin's formula relates the wavelength $\lambda$ of the vibrations to the excitation frequency $f$ [2]:

$$\lambda^3 = 2\pi \frac{\sigma}{d f^2}$$

where $\sigma$ is the liquid surface tension and $d$ the liquid density.
In addition, Lang [3] has established the following relation which means that the mean diameter $\Phi$ of the droplets is a function of the excitation frequency and the characteristics of the liquid:

$$
\Phi = k \left( \frac{8\pi\sigma}{d f^2} \right)^{1/3}
$$

where $k$ is a constant. For example, the mean diameter of the droplets is 4.5 $\mu$m for water and 3.6 $\mu$m for butanol at 800 kHz.

Figure 1. Geyser and aerosol.

2.2. Process mechanisms

The various modes of decomposition of the aerosol are illustrated in figure 2 in relation to temperature or droplets size. The major fraction of the aerosol must be a gas when it contacts the substrate (CVD). If the droplets are too large, they will not have time to vaporize completely (liquid-solid reaction). It is also the case if the temperature is too low. If the droplets are too small or if the temperature is too high, the droplets will have already been decomposed by pyrolysis (solid-solid reaction). So, the process success lies in the formation of a narrow spectrum of fine droplets. The use of ultrasonic spraying is the warranty of a monodisperse aerosol with controlled droplets size leading to a CVD like reaction.