Flokal® expands and proudly presents new service – Liquid precursor delivery and vaporization

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New Flokal® technologies

- CVD Background;
- Precursor delivery into reactor.
- Conclusions

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New Flokal® technologies

CVD background

The rapid growth of the hi-tech technologies allows solving the ensemble of the problems, which appear due to influence of the economic laws on purposes and problems of the industry.

Amongst collection of the hi-tech technology, there are some of the most attractive and perspective, from the economic and technical standpoints. Amongst them there are technologies of precision grown of a heterostructures - molecular-beam epitaxion (MBE) and chemical vapor deposition (CVD).

These technologies have allowed proceed with creation laminated hetero-structures with sharp interface and size of the active areas comparable to wavelength of the electron. Hetero-structure (the film) in fact is a monocrystal, in which is inserted layer, diversified by chemical composition from composition of the matrix.

MBE and CVD became essential booster of the work on making the row of instruments of the rapidest electronics. For instance, we can take the technologies of the creation hardware components in IT industry. It's known, that in needs of the processing bigger volume of information in more short time brings about unceasing complication of the integral schemes and increasing of the speed of each separate element. The traditional way of the speed increasing - a reduction of the sizes and increasing the density of the packing becomes all more not efficient, is since reached all more expensive price. Besides this, there are some limits of the elements reduction, which depends from technological and physical restrictions. In such conditions, absolutely obvious way of the speed increasing is an increase the velocities of the carriers. Turned out to be that, only use of the films, which built on MBE and CVD technologies, has allowed realize this in real tools.

As it was already noticed, there are two main methods and two types of the equipment, which with equal success are used for films making.

Chemical vapor deposition (CVD). In reactor, which has rather complex installation are located several substrates (be-that GaAs, saphire or something else). The substrates (the circles) - such thin cuts of the monocrystal, to which flow "thundering mixture" (complex, usually powerfully combustible) and under high temperature makes a reaction with substrates. As a result, layers shaping of the film occur - a layer of the molecules beside a layer of the molecules. With this method, for instance, wide-zone semiconductors materials on GaN base are grown (for example, structures for fabrication blue-green photodiode or that the short-wave laser for new generation CD-ROM).

Other method is MBE or molecular beam epitaxion. It is based on high-vacuum installation, which has a big sizes and according to this it is possible to dispose the enormous amount of the substrates. From special parts molecular flow gets on substrate. It can be modulated with a special damper, and this allow on surfaces of the substrate film grow.

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The most wide-spread in present time are CVD systems (fig. 1), which unite in itself voluminous collection of sub-technologies (LPCVD, APCVD, MCVD, ESAVD, MOCVD), which quantity grows, as result of the influence and combinations of other physico-chemical technologies with CVD technology.

By means of CVD technology big amount varied laminated films is produced.

Figure1. Schematic view of CVD technology.

Earlier science and technology were oriented on thermal actuated CVD process. But, new start of the direction in plasma actuated processes was recently realized.

This is connected with that, that presently whole technology is orientated on low level temperature processes. It is joined with need of the improvement quality of the films. Diffusion is excluded in such low level temperature process.

In some CVD processes gaseous precursors are traditionally used. However, at present time, liquid precursors are often used instead of gaseous ones. The reason is physical properties of liquid precursors. They are less harmful, flammable, corrosive and poisonous than gases. On the base of liquid precursors one of the most perspective CVD technologies (MOCVD) is developing. MOCVD is a metalorganic chemical vapor deposition, which had extremely development at the last 10 years.

Precursor delivery into reactor

Special question, which has to be described more wide, is precursor delivery into reactor.

There are several technologies of precursor delivery into reactor. Amongst them, there are two main technologies: bubbler delivery system and direct liquid injection. The first of precursor delivery methods into reactor is a bubbler delivery system. Essence of this method is concluded in following. The vapor is obtained and then transported through heated gas lines into the reactor. The flow of vapor is directly related to the vapor pressure in the container, which varies with temperature, according to the characteristics of the liquid. Main fault of bubbler systems is the sensitivity to temperature and, as result, poor reproducibility and instability of the vapor flow. There are two basic configurations of bubblers: with and without carrier gas. In configurations without using a carrier gas the resulting flow of vapor depends from vapor-pressure characteristics, i.e. on temperature of precursor. But many complex precursor sources change their evaporation rates when heated over an extended period of time and generally can break down.

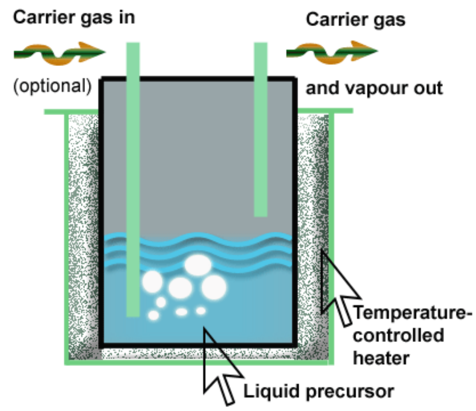

Figure 2. Schematic view of a bubbler delivery system.

Other bubbler system configurations use a carrier gas and operate by bubbling a carrier gas through a temperature controlled liquid.(Fig. 2) There is formation of small bubblers of carrier gas in the liquid, in which vapor quickly attains its equilibium vapor pressure as the bubbles float to the liquid surface. The amount of vapor delivered is determined by carrier gas flow and the temperature of the liquid. Temperature control is critical and indispensable for accurate vapor delivery even when the nominal liquid temperature is set at room temperature. Although there are many sophisticated bubbler systems with accurate and reproducible vapor delivery and many other improvements, temperature control remains critical.

The second precursor delivery method is a direct liquid injection (DLI).

DLI system has many benefits, when we compare it with bubbler delivery system. It provides accurate, stable control of precursor delivery rate. Temperature control is much less critical as for the bubbler systems. With a suitable solvent, a variety of precursor compounds can be used, including solids and other compounds not suitable for vapor delivery. For instance, on fig. 3 there is a view of direct liquid inject system.

Direct liquid injection systems can be made by 2 ways.

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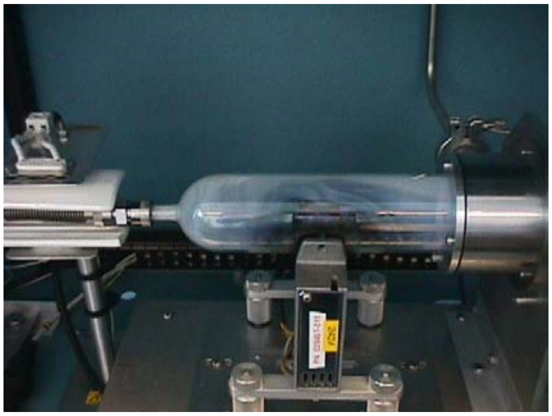

Figure 3. View of direct liquid inject system.

First of them is using pumps (piston in cylinder) for liquids control displacement. In such method for avoiding interruption of the flow while refilling the cylinder, two cylinders are used. The liquid can mix with the carrier gas prior to streaming to the evaporator, but more attractive is the following way: the liquid flows to evaporator through which flows carrier gas. This ensures heating of the liquid and evaporation into the carrier. The amount of vapor delivered is not sensitive to the exact temperature of the evaporator. It is really difficult to make the liquid injection system in which two cylinders exactly matched. That's why there are a lot of advanced systems (e.g. dual-piston micro-stepper motor driven metering pump which delivers liquid in a smooth pulse-free manner).

Second way is using of a thermal mass flow controller which can be used for liquids just for a gas and can measure liquid flow. The liquid, controlled by the mass flow controller, is typically pressurized to flow to the evaporator using a carrier gas. Temperature and pressure are only boundary conditions. The only criterion is that the partial pressure of the fluid must be lower than the vapor pressure at that temperature to prevent condensation. Such systems need a minimum flow of gas to carry the liquid into the heated evaporation zone. Flows are stable, repeatable and easily adjustable via the mass flow controllers. Schematic view is on Fig. 4.

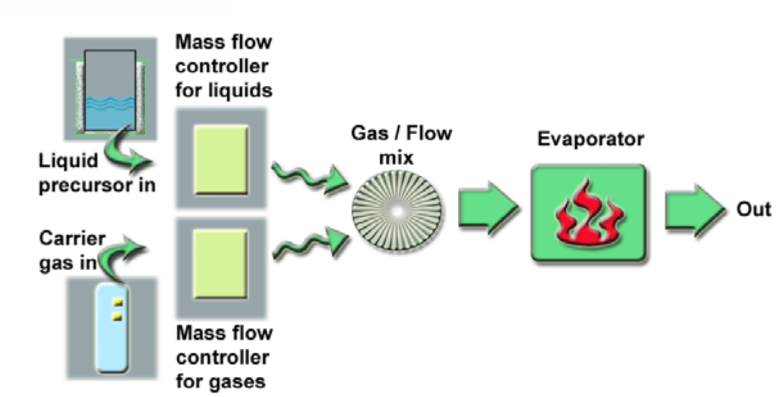

Figure 4. Schematic view of liquid delivery system, based on mass flow controllers.

Most advanced systems for direct liquid injection turn liquid precursor (which keeps at room temperature) directly into evaporator without assistance of a carrier gas and perform non-contact evaporation. Evaporation via direct contact to a heated surface can lead to undesirable particle and memory effects. Non-contact evaporation allows avoid completely residual material on a hot evaporating surface and consequently provides highly repeatable characteristics and long term process stability.

In such systems carrier gas is injected independently into evaporator and aids in the delivery of low vapor pressure precursors into the reactor. Non-contact evaporation is achieved by injection of precisely controlled doses of liquid precursors into the heated carrier gas, to be efficiently evaporated without any residue.

Conclusions

Development of MOCVD technology shows the increased use of liquid source materials or solids dissolved in liquids. These liquids and dissolved solids are viewed as critical to the advancement of semiconductors, ferroelectrics, superconducting materials, fiber optics.

For using of these liquid precursors in CVD and MOCVD processes, liquid precursor delivery and vaporization systems were developed, which cover a very wide range of scientific and industrial applications. Such systems enable a number of precursors to be used, including thermally unstable ones which can break down when held at high temperature.

The main advantages of liquid precursor delivery and vaporization systems are accurate control of precursor delivery rate, fast response, high repeatability, good stability, low working temperature, possibility to operate under different pressures.

Liquid precursors can be remained at room temperature. Thus, liquid precursor delivery and vaporization systems are mush attractive for using in CVD and MOCVD applications.

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