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Computer controlling of MOVPE process

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The metalorganic vapour phase epitaxy (MOVPE) technology requires precise control of growth process. Systems designed and built in our laboratory are equipped with two microcontroller-based device. The first one is used for driving pneumatic valves, mass flow controllers and pressure controllers, the second one is responsible for PID control of epitaxial reactor temperature. This paper describes the software designed to supervise both of these devices in order to make using of MOVPE system more efficient and less error-prone, as well as to provide help in emergency situations.

1. Introduction

To obtain a high quality final effect during semiconductor layers deposition using MOVPE technique a few important conditions must be satisfied. These include precise growth conditions control and rapid changes of gas atmosphere in an epitaxial reactor, which should be shorter than single monolayer growth time, *etc*. Only modern MOVPE systems, equipped with precise mass flow, pressure and temperature controllers, as well as fast pneumatic valves, can meet these requirements.

The MOVPE system designed and constructed in our laboratory has been previously described [1], [2]. The fact of the large number of parameters that have to be controlled, as well as high speed of their changes, is the main reason for using microcontroller modules as drivers for the entire system. Each module takes care of setting a few controllers and valves, and their actions depend on process description written in the controller's internal language. In case of a system upgrade the number of modules may be easily changed.

With a high number of experiments being performed on described MOVPE system, we have soon realised that an external computer is required that would act as a supervisor for the microcontroller driver. The MS-Windows application called EPI has been created for both on-the-fly controlling and diagnostics of MOVPE process being run. The software of that kind is widely used with commercially available MOVPE systems.

2. EPI program

Relations between main parts of our MOVPE system are schematically shown in Fig. 1. Mixing system and RF power generator provide proper growth conditions inside

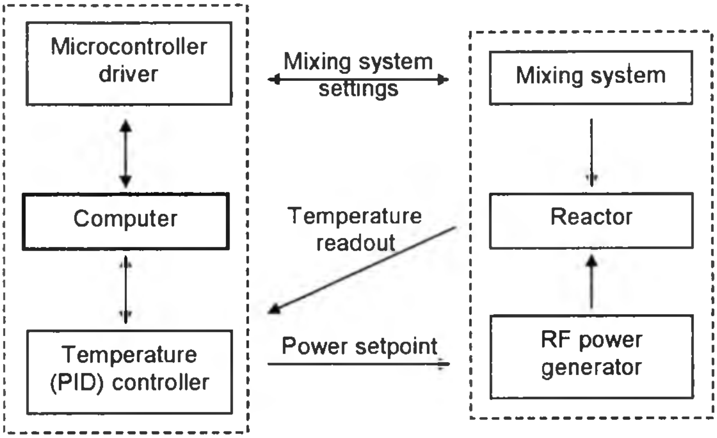

Fig. 1. Relations between the parts of MOVPE system.

an epitaxial reactor. Mixing system is driven by a microcontroller-based device, while PID controller controls RF power generator. Both microcontroller driver and PID communicate with a personal computer using RS 232C serial interface.

Microcomputer program sets/reads temperature and controllers settings, as well as MOVPE process description programs. Its main features include a user-friendly graphical interface for process editing, on-the-fly readouts and controllers state change display, process procedure verification and process run recorder functions.

The process editor screen is shown in Fig. 2. For each stage of the process it is necessary to set its duration and all controllers and valves settings. The editor is easy

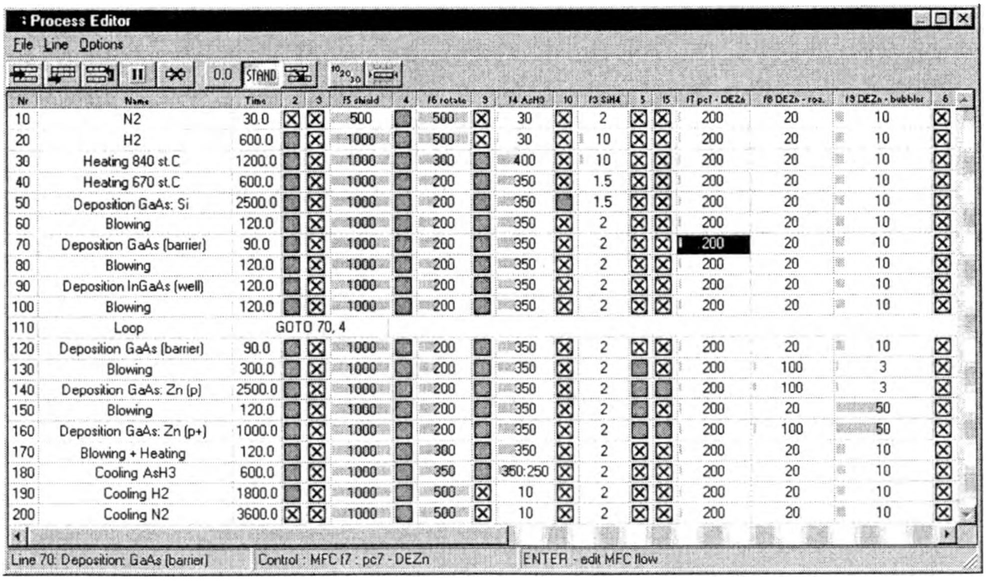

Fig. 2. Process editor.

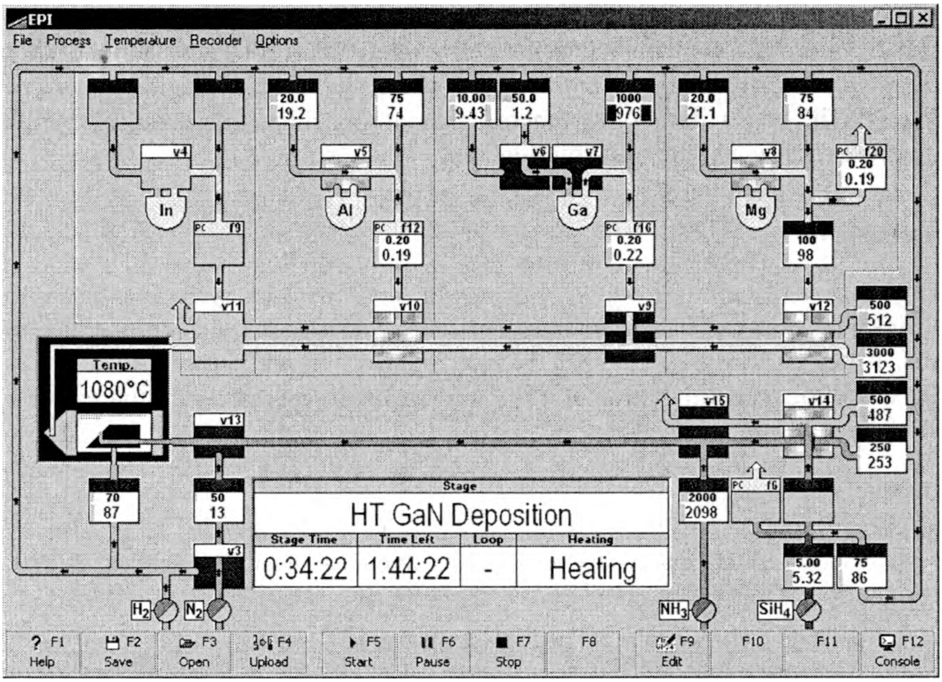

Fig. 3. Main screen.

to use utility that simplifies the process program creation procedure. Thanks to its graphical interface with a set of common editing functions, this task is much easier and less error-prone than preparing files directly in the microcontroller driver's internal language.

Main program screen, shown in Fig. 3, is displayed during process execution. For convenience, current pressures, flows and valve settings are displayed over a mixing system diagram. Actual values are compared with values desired and the engineer is alerted if differences found are too big. The engineer can intervene in the process at any time and can change a desired controller setting just by pointing on its icon and typing a new value.

EPI program is not only a simplified interface for the microcontroller driver, but it also provides some additional functions not supported by the driver itself. A recorder can be used to store actual flows, pressures and valve settings throughout the whole process for later analysis. Recorded values may be displayed in spreadsheet on graph form. Recently, we have used it to examine temperature response of our new MOVPE reactor. It is also useful to recall the actual run history in case of some minor device malfunction or when the engineer manually changes process settings during the growth process. There is also a process verification function which checks whether a process program in the microcontroller driver memory matches the process to be carried out.

The other vital functions are automatic stage skipping after a desired temperature has been reached or stabilised and fast selection of pre-defined controller states. First of them is important when it is necessary to change temperature and continue with the process as soon as possible (but under stabilised temperature conditions), and the latter is very useful in cases of emergency, when lots of controller settings should be changed immediately. The driver itself only supports instant switching to a stand-by mode, which in most cases is not the best solution.

3. Conclusions

The application of EPI program has greatly extended our MOVPE system features. As it simplifies controlling of the microcontroller driver and adds some additional useful functions, it becomes a useful tool in process preparation and supervision. It also helped in detection and elimination of a few system faults, especially during our new MOVPE system set-up phase.

References

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