



**PETR ADÁMEK**

## **Construction of Dip-Coater**

Doc. PaedDr., Ph.D., University of South Bohemia, Faculty of Education, Department of Applied Physics and Technology, České Budějovice, Czech Republic

### **Abstract**

This paper describes construction of the “Dip-Coater”. The Dip-Coater serves to preparing of thin layers in liquid solutions. The instrument holds the microscope slide and dips it into active solution matter by defined velocity. The sample is dipped in the active solution matter for adjusted time and it is pulled out also with defined velocity. The developed and functionally approved system was primarily applied in experimental deposition of thin layers. The system offered the real opportunity of successful applications in scholar tasks in educational process. Subjects that can contribute to the development and construction of the system are the technology education of machinery the applied electronics and computer science. Another aim of the idea is the exploration of the existing or developed instruments and machines in educational process. The process should be realized by the interactive observation and researching of machines focused to their principles of function and their construction. Obtained theoretical knowledge and practical skills should be applied in construction of the other devices with the same or similar principles but with different purpose. The project also includes development of own electronic controlling and interface circuits and original software.

**Key words:** Dip-Coater, experimental device, educational process, technology education, computer science.

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### **Introduction**

The requirements of construction of the special device arose out of process of experimental deposition of thin layers. For this purpose exist commercial Dip-Coater machines [<http://www.mtixtl.com/dip-coater-desktop.aspx>] those devices are described and offered also at page [<http://www.nadetech.com/index.php/en/products/dip-coater>]. Offered commercial experimental device for creation thin layers in liquid matter are usually relatively expensive. Our system of the Dip-Coater was developed and constructed to compare quality of thin layers produced by other techniques [Kment et al. 2008: 2379–2383]. The plasma deposited thin layers were tested in comparison with layers prepared in solution matters. Alternative solution of the requirement of the experimental device was in approach to the development of the device in practical teaching of technology or physics [Adámek, Tesař 2014: 130–139]. First task was the selection and

adaptation of mechanical parts. Mechanical parts are namely the chassis the vertical moveable carriage the carriage guide rod the slide-sample holder the acceptable stepping motor with gear box and the transmission belt. The second task was the constructing of “user friendly” control system with electronic state machine or microcontroller. It includes programming of the software for controlling of velocity of the movement of the moveable carriage and the time intervals for the dipping. Another electronic part was consisted of the construction of the supply power module for stepping motor the power switches and the position detectors. The position detectors indicate the carriage vertical positions and position of the sample holder. The first experimental solution of wiring of the simply state machine seemed to be very economical technological and progressive solution. But in accordance with another requirement of the Dip-Coater experiments the device must be capable to save protocol of experiment or history of the dip-coating process. Therefore must be taken into account inserting of the comment of the saving of all elapsed time intervals and information of adjusted velocity of the sample holder of the performed experiment. All the parameters may be saved into ASCII data file. This important deficiency has eliminated the application of the simply state machine or the microcontroller. The final and “user friendly” solution was the application of PC with using of standard interface [Adámek 2004: 444–448; Fríd, Adámek, Frolík, Blažek 1999: 27–30]. The block diagram of the Dip-Coater is depicted in the Fig. 1.

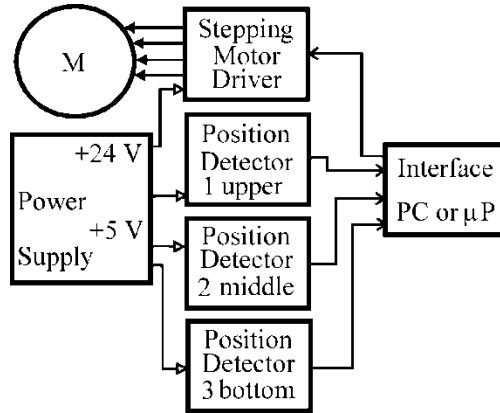
### **Dip-Coater chassis**

The main part of the chassis of the Dip-Coater consists of vertical steel cantilever with mounted cylindrical guide rod. The guide rod was dismounted from the used printer. On the cylindrical guide rod is moved the modified printer carriage. On the carriage is attached the sample holder. The Vertical movement of the carriage performs the moving belt that is lead on the pulley and the driven sheave. The sheave is driven by stepping motor over the gear box. The positions of moveable carriage are detected by three at place adjustable photo sensors in the upper position in the middle position and in the bottom position. All the vertical positions of the samples may be preciously adjusted by the controlling program for the stepping motor.

### **Stepping motor driver**

The stepping motor driver consists of the power supply module and of the power switches. The power supply consists of transformer of 10 VA 230V/15V with AC unloaded output voltage of 18 V. The isolation transformer is tested at 4 kV. Supply voltage is stabilized at 5 V DC voltage level. Function of the power supply is indicated by LED on front panel of the switching unit. The switching unit drives through the interface and by photo-couplers the coils of the step-

ping motor. The switching circuits with transistors are working at DC non-stabilized voltage of 24 V. Theoretical switched current intensity is up to 2 A. The Switching transistors are controlled by the DATA bit 0, bit 1, bit 2 and bit 3 of output register of Standard Parallel Printer Interface. That is lead to the pin 2, pin 3, pin 4 and pin 5 of the female connector CANON 25 at the rear side of the PC.



**Fig. 1. Block diagram of the Dip-Coater**

### **Interface and control unit**

The discarded personal computer or the industrial computer was applied as the control unit. The Dip-Coater motor driver unit is connected to the system board of personal computer by the parallel interface in the [[http://www.interface-bus.com/Design\\_Centrronics\\_Connector\\_PinOuts.html](http://www.interface-bus.com/Design_Centrronics_Connector_PinOuts.html)] standard mode. The parallel interface and all the switches are also isolated from controlling computer by photo-coupler – isolators. Isolating voltage of the applied photo-coupler is guaranteed by producer up to 5 kV [<http://www.ges.cz/cz/pc817-GES05114567.html>]. The motor driver is directly controlled by output DATA register of base address port e.g. 378<sub>h</sub>, 888<sub>d</sub>. The vertical position of the carriage with the sample holder is detected by three sensors with photo detectors. The signal of the position limit photo detectors is read into input state register at address (base address + 1) e.g. 379<sub>h</sub>, 889<sub>d</sub>. The upper position detector is read at pin 11 (signal “BUSY”) of female connector CANON 25. The middle position detector signal is read at pin 10 (signal “ACK”). The bottom position detector signal is read at pin 12 (signal “PE”). Pin 13 is grounded and pin 15 is lead at + 5V by resistor 10 kΩ.

### **Software support and operation**

The software support is developed for the inserting of experimental parameters and controlling of the dipping process. User inserts firstly by the controlling program the value of the velocity of the vertical movement of the sample holder

up and down and the dipping time. The process is started immediately by pressing of the start key. The Dip-Coater automatically moves the sample holder into upper start position. The new sample(s) are manually inserted into sample holder and the program performs automatically the dipping of the sample into solution matter. The sample is hold in the active solution for the set time long and the sample is then pulled out by the preset velocity. The sample holder is stopped in vertical limit position and the sample(s) are exchanged. The process may be repeated under the same conditions or under changed conditions. User can save the set parameters and add own comment into history file.

### **Achieved parameters and conclusions**

The developed programmable Dip-Coater can to dip the sample(s) into and to pull it out of the solution matter. Maximal movement range of the carriage is 220 mm. The velocity of the sample holder is adjustable by the program from  $0 \text{ mm}\cdot\text{s}^{-1}$  to  $20 \text{ mm}\cdot\text{s}^{-1}$ . The dipping time is possible set in the range of 0 ms to 32767 s. Upper position of the sample holder is adjustable by position detector. The level of the solution matter is adjustable by the middle position detector. The depth of the sample dipping is adjustable by the bottom position detector. The depth of dipped samples in the solution matter may be preciously adjusted by software controlled stepping motor. Information of the applied experimental parameters, comment and information about real time of beginning and finishing of the process may be saved into history ASCII file. Software support may be developed in random programming language. Connection with industrial computer is managed by standard interface – easiest application is the parallel interface. The switching unit with the developed program makes possibility of the controlling several types of stepping motors. Last but not least is economical effect of costs. The cost of the commercial systems achieves 1000 USD and more. It is obvious that mentioned device may be successfully applied in education process. The developed Dip-Coater is as the simply industrial manipulator suitable for explanation and presentation of its function. The device is also hardware compatible to newest microprocessor kits. It is possible directly connect the stepping motor driver and the position detectors to the digital input and output contacts of the microprocessor kits. Developed software for any application may be adapted to the requirement of the experiment of the educational process.

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