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Construction of An Open Loop Temperature Control System for Thin Film Fabrication in PC Based Instrumentation

K.Tamilselvan[*,1] , K.Anuradha[2], S.Deepa[2] , O.N.Balasundaram[2] and S.Palaniswamy[2]

[*,1]Department of Electronics, PSG College of Arts and Science, Coimbatore-641 014.
[2]Department of Physics, PSG College of Arts and Science, Coimbatore-641 014.
E-mail: tamilselvan.psgarts@gmail.com

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Abstract

The paper describes an open loop control for controlling the chemical hot bath temperature in PC based dip coating system for thin film fabrication. The control of temperature is achieved by changing the duty cycle and supply voltage. The function of the duty cycle at each supply voltage in obtaining maximum temperature is studied. The open loop control of temperature is implemented using PC based instrumentation. The temperature control system is optimized using relation between the duty cycle and temperature. The performance of this system is compared to that of a conventional close loop controller on a laboratory test. Results are presented that shows a good control of the hot bath temperature.

Keywords: open loop control, PC based dip control system, duty cycle.

INTRODUCTION

The use of personal computers in automation systems is widespread. The realization of PC-based automation systems has been allowed by several factors, among them are-

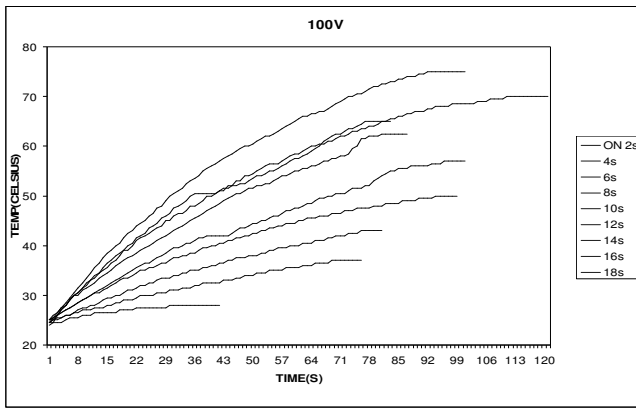
1. The impressive grown of the PC's performances which ensures the possibility of locating and executing, inside the same machine, both the types of tasks involved: real-time control and monitoring /supervision.
2. The use of high level language allows for an efficient scheduling of the tasks assigning higher priorities to the most critical ones.
3. Increasing availability of devices equipped with bus interfaces which makes possible, the realization of an automation system using hardware/software products of different manufacturers.

In the first part of this paper, we describe the general structure of the PC-based dip coating unit with open loop temperature control and an experimental evaluation of its performance using PWM technique.

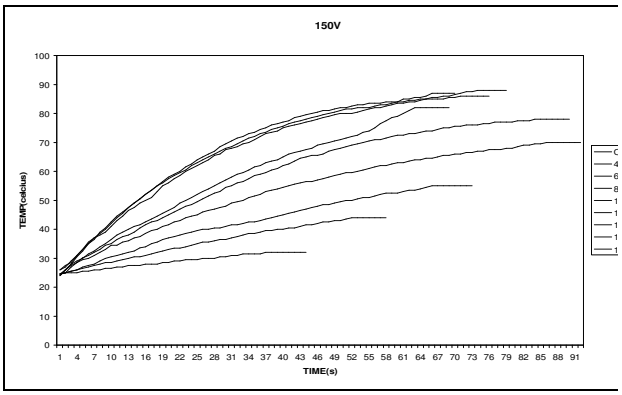
MATERIALS AND METHOD

A Personal Computer with Pentium processor, 256 MB RAM and 80 GB Hard disk drive along with external driver circuits are used. A small mechanical arrangement driven by stepping motor is used to move the substrate upward / downward. The stepper motor drives the screw rod, moving pulley and substrate holder. The proper gear reduction mechanism and well polished gear teeth wheels are employed to avoid mechanical slip and jerk. The screw rod is precisely machined to give smooth upward and downward movement. The control signals are taken from printer port or Programmable Peripheral Interface (PPI) card. Transistor driver controls the voltage applied to heater of hot bath. The programs written in C++ are executed. The instrumental setup is shown in figure.

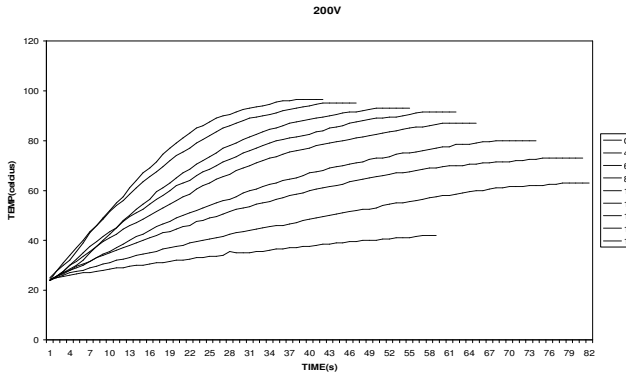
Fig.-1: Instrumental Setup



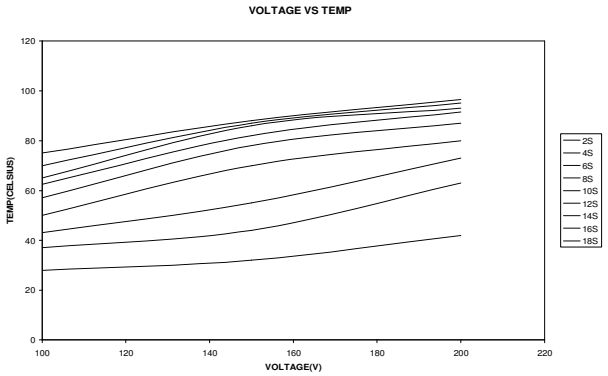
Graph- i: Variation of temperature with time for 100V and .05Hz for various duty cycles.



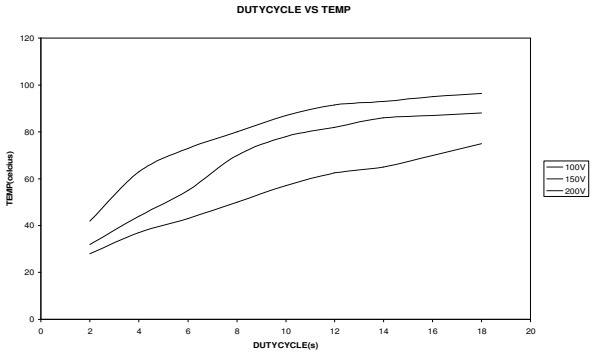
Graph-ii: Variation of temperature with time for 150V and .05Hz for various duty cycles.



Graph-iii: Variation of temperature with time for 200V and .05Hz for various duty cycles.



Graph-iv: Plot with voltage and temperature for various duty cycles.



Graph-v: Plot with duty cycle and temperature for fixed voltages.

Fig.-3: Different Graphs

RESULTS AND DISCUSSION

Temperature control

The temperature of the hot bath can be controlled by two methods namely,

i. Closed loop control and
ii. Open loop control

Closed loop control

Closed loop control system requires a sensor, a feedback circuit and a complex controller circuit, which is a drawback of the closed loop control. On the other hand the temperature control in this system can be done very precisely with a variation of 1ºC or 2ºC.

Open loop contropl

An open loop control is simple.It does not require a sensor, a feedback circuit and also a complex circuit, which adds to the advantages of a open loop control. It requires only a driver circuit to control the temperature of the hot bath.
In this system, temperature control can be done by using PWM technique , ie

i. by varying the duty cycle
ii. by varying the frequency

where,

Duty cycle = ON time/ Total Time

when the duty cycle decreases the output voltage also decreases and when the duty cycle increases the output voltage also increases.

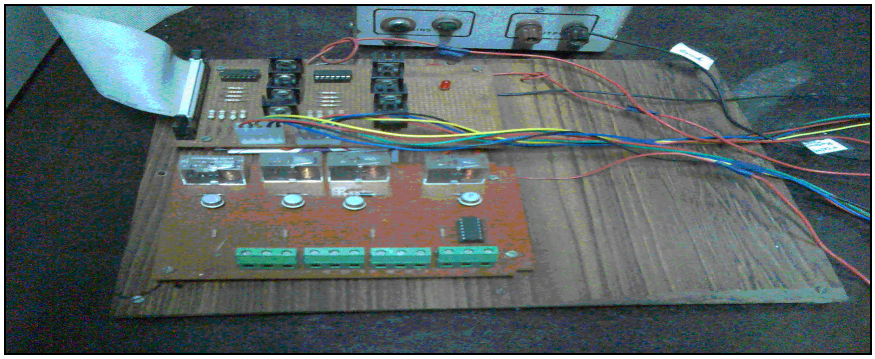


Fig.-2: Driver circuit

Optimization

The temperature of the hot bath varies accordingly with duty cycle, frequency and the supply voltage.The change in temperature of hot bath for fixed interval of time is studied until the temperature of the hot bath reaches the saturation temperature for fixed frequency and supply voltage . The change in temperature is plotted, graphically.
For a supply voltage of 100V the saturation temperature is minimum and varies according to the duty cycle. Similarly for 150V and 200V the saturation temperature varies according to the duty cycle.
From these observations we can fix the required temperature of the hot bath by fixing the corresponding duty cycle and the voltage.

CONCLUSIONS

This newly designed simple instrumental setup is cost effective and convenient for preparation of Thin Films. The well known technique PWM is used to control the temperature. By changing the ON time and keeping the TOTAL time unchanged, the temperature can be increased or decreased. The proper mechanical setup and programming techniques improves the system performance.

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