Cost Effective IoT Enabled Automation of Spray Pyrolizer

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Abstract - *The concept of cost effective IoT enabled automation is based on the principle of 2-D Cartesian printing. It involves setting up a plotter like arrangement with the spray nozzle on the X and Y axis movement rail. So that the required thin film of any area or any pattern can be coated. This saves the time in coating the thin films for research purpose and it is also accurate in the dimensions. The notable advantage is that the entire setup can be placed in a vacuum chamber so that the there is no atmospheric deposits on the thin film and the solvent along with the impurities vaporises more accurately at the set temperature. This quickens the process of research giving the desirable results at a cost effective and in an efficient manner*

***Key Words*: 2-D Printing, Arduino, Automated, IoT Raspberry Pi, MATLAB Analytics, Remote Access, Spray Pyroliser, Thingspeak.**

1. INTRODUCTION

Spray pyrolysis is an important process based on chemical vapour deposition in the synthesis of thin films. The synthesized thin films have varied applications ranging from solar cells of CZTS, CDTS, CIS and perovskites. The spray pyrolysis technique when automated along with IoT in such a manner that there is as much accuracy and control over the physical parameters, the spray pyrolysis cost is cut down. The researcher can obtain the analytics of the data, control the parameters and perform the experiment from any remote location. This enables research laboratories make use of the equipment to synthesize thin films in a cost-effective manner and fostering collaborative research and development online paving the way to the next generation in thin film technology.

2. COMPONENTS REQUIRED

Table -1

S NO	COMPONENT	QUANTITY
1.	Arduino UNO	1
2.	Stepper motor	2
3.	Plywood	As Required
4.	3-D printed Enclosure	7 Pcs
5.	Driver shield for stepper motor	1
6.	Heat sinks	2
7.	Soldering iron	1
8.	Raspberry Pi camera	1
9.	Regulated Power Supply	1
10.	GT2 Belt	1
11.	Raspberry PI 4B	1
12.	LM8UU bearings	6

3. SCHEMATICS

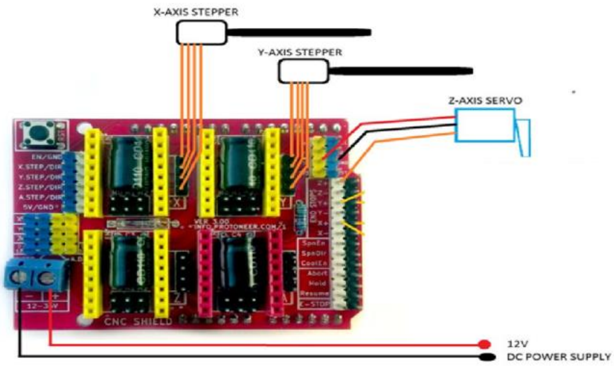

Fig -1: Simplified representation of the circuit from the Shield

4. METHODOLOGY

The necessary support for the X axis and Y axis guidelines is constructed according to the desired dimension from plywood. In a professional level the components may be designed using Solidworks and using any slicing software the frame can also be 3D printed. The support for the X axis guide way is setup. Between the mounts faced opposite to each other a bolt of required length is inserted along with two nuts. The long bolt is connected to one end of the microcontroller-controlled stepper motor. To support the Y Axis Guide over the X axis, guide another similar arrangement is made from a thin stain less steel rod instead of a screw. A plastic hollow cylinder is inserted into the stainless-steel rod for free movement. The two nuts in the previous arrangement and the hollow cylindrical cap is connected using a wooden/plastic support. The Y axis guideway is prepared in the exact same way as the X axis guideway. The Y Axis guideway is mounted over the X axis guideway. The Stepper motor for the X axis drive and Y axis drive are setup. Over the microcontroller board a Driver shield board is used for the stepper motor as the rating of the stepper is much higher than that of the output in the microcontroller board. The Voltage regulators are fixed with suitable heat sinks to prevent thermal runaway of the components. Cooling fans are attached temporarily to the prototype to ensure proper heat dissipation. The pattern or the area of the coating of the thin film is designed using a CNC laser cutting software and it is interfaced into the integrated developer environment of the microcontroller. The nozzle of the spray pyrolizer is fixed over the holder. If the thin film to be coated needs a pattern then a suitable holder similar to that in a cd drive is used to lift off the spray pyrolizer nozzle when a discontinuity is required

5. OPERATING MECHANISM

The pattern of the film to be coated is designed using Benbox - a CNC LASER engraving software and it is interfaced with Arduino which gives the necessary signal input to the stepper motor to control the movement with precision. In order to simplify the equipment, it is Wi-Fi Enables with ESP8266 module. It enables the automated spray pyrolizer to be controlled from a mobile application. The Arduino microcontroller interfaced to the sensors and stepper motors is connected to the Raspberry Pi, enabling the remote access of the instrument. The deposition parameters can be varied remotely.

6. SOFTWARE

The device is controlled using "Benbox laser engraver" software. A custom-built firmware built for Arduino Microcontroller is used for the basic mechanical control. Any pattern required can also be designed using the software besides uniform rectangular coating of thin film over a glass slide. This same procedure can be used to coat thin films on a commercial level on surfaces that are not necessarily rectangular

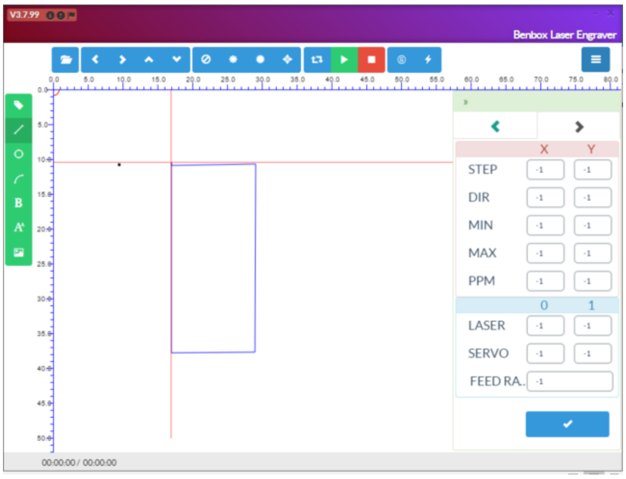

Fig -2: Design of the thin film coating

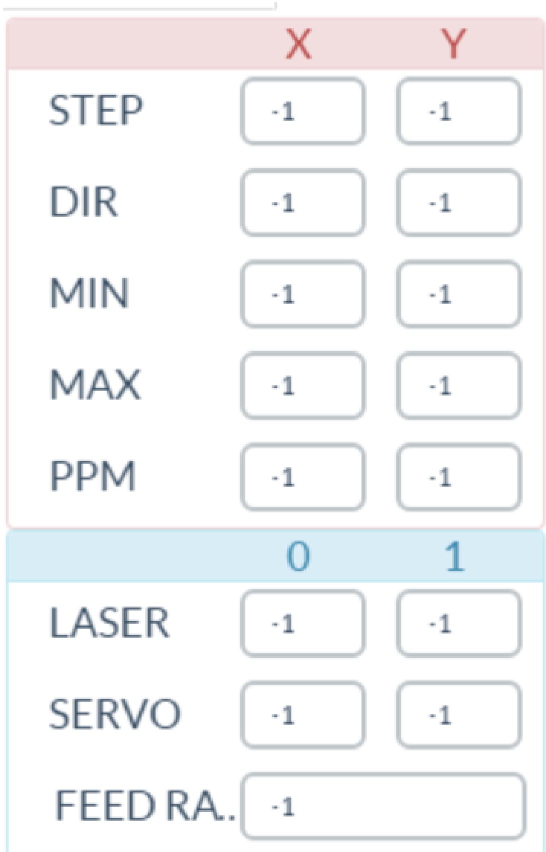

Fig -3: Control interface for the stepper, servo and spray sequence

7. IOT PLATFORM

In order to enable IoT capabilities the cloud platform offered my MathWorks called "Thingspeak" is used. This cloud platform also has MATLAB Analytics [1] [2].

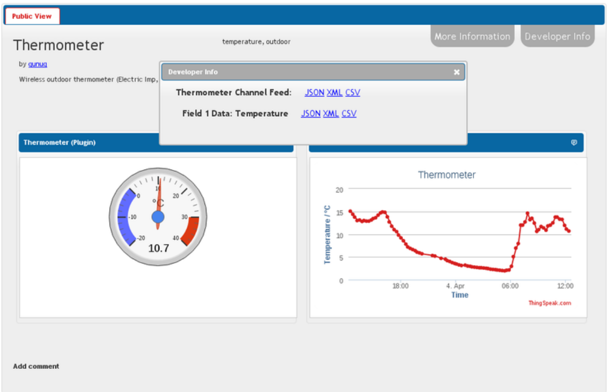

Fig -4: Monitoring of Temperature Parameter over cloud

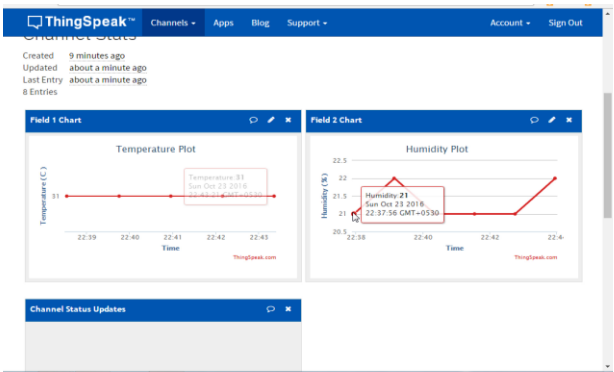

Fig -5: Plot from the data uploaded from a DHT11 sensor

This platform provides the flexibility of adding different output channels for simultaneous monitoring of several parameters. A mobile application can be interfaced with this platform for quick monitoring of the parameters from any place

8. SCOPE FOR FURTHER IMPROVEMENTS

The instrument can be IoT enabled by using a free cloud platform called "Thingspeak". By bringing in IoT capabilities to the instrument it can be easily interfaced with LABVIEW and the observations of different parameters can be manipulated automatically and statistically recorded. The results of the research can be shared in a secure cloud platform when a mini private cloud server is interfaced with the laboratory. This will enable the collaborators in different parts of the world to work together in developing a new technology using this new cutting-edge approach towards the automation of laboratory instruments.

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[2] https://thingspeak.com/channels/public