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THE AUTOMATIZED SYSTEMS FOR SPRAY PYROLYSIS DEPOSITION

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Abstract: The paper presents the parameters of the deposition technique, describe the process of the spray pyrolysis deposition, calculation of the costs for manual and automatized systems which are used for spraying. In this paper is presented an example where the manual system can produces 90 units/h and the automatized system can produces 50 units/h. The problem in the deposition experiments is the reproducibility and automatic SPD is imposed.

1. INTRODUCTION

The aim of this paper is to develop an automatized system which can cover plane surfaces by using spray deposition. The major drawback of the actual generation of the photovoltaic solar cells is their laborious, energy consuming, and costly production.

At this moment the reserch and manufacture of ceramics solar cells is made manually with SPD (Spray Pyrolisys Deposition) devices. Therefore, and automatic device able to control all the parameters during the deposition is required. The coating process done with the manual installations is a low efficiency process because of a lack of accuracy and too much time needed. Because of that, the automatization of the mouvements for coating a range of different surfaces and different forms is imposed.

The structure and the complexity of the installation's mechanical system are determined by the necessary movements in the spray pyrolysis process. The automatic installation for deposition of nanolayers for renewable energy sources applications will accomplish the spraying process a lot easier and faster, providing the repeatibility, a needed feature of nanolayers.

2. INFLUENCE OF DEPOSITION PARAMETERS ON THIN FILM PROPERTIES

Thin-film deposition, using the spray pyrolysis technique, involves spraying a metal salt solution onto a heated substrate (Fig. 1). Droplets impact on the substrate surface, spread into a disk shaped structure, and undergo thermal decomposition. The shape and size of the disk depends on the momentum and volume of the droplet, as well as the substrate temperature. Consequently, the film is usually composed of overlapping disks of metal salt being converted into oxides on the heated substrate [3, 4].

Uniform deposition of the layer depends on the process steps which follow the deposition. Step coverage is the capability of a process to deposit equally thick films on steep slopes and on flat surfaces. The degree of step coverage is determined by the chemistry/physics of the process. The films must remain stable during these process steps. The problem is the reproducibility of the process, that's why an automatic installation of SPD is imposed.

To be controlled during the spraying process to obtain a nanolayer with a good morphology and a homogenous structure, [3, 4]:

- the precursor's composition,
- the surface temperature,
- the spraying sequences,
- drops dimensions,

– the angles and the direction from which the spraying process is accomplished.

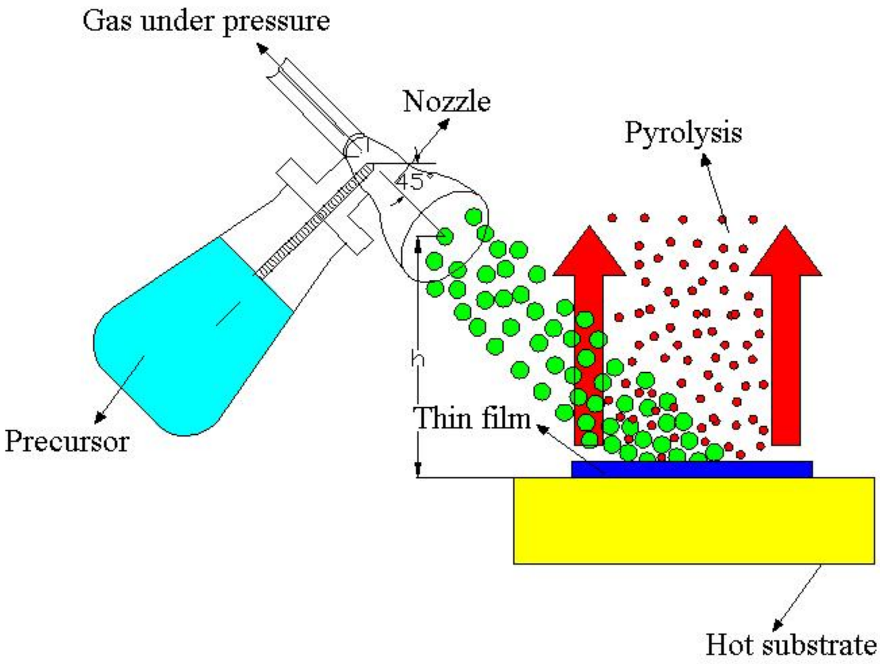

Fig. 1. Schematic diagram of spray pyrolysis equipment

The precursor's composition, drops dimensions, surface temperature can be establish at the start of the spraying process. From the mechanical point of view the precursor's composition and drops dimensions are not important. They are established by chemists that will work with the installation. The surface temperature can be controlled with a thermocouple. The angle and the direction of the spray remain critical factors in obtaining homogenous nanolayers. And they depend of the flexibility of the mechanical structure.

The advantage of moving the nozzle in x-y plane makes the installation cost effective. We don't have to spend energy moving the table with the hot plate integrated and all the electrical connections. The nozzle system is very lightweight.

Spray pyrolysis involves many processes occurring either simultaneously or sequentially. The most important of these are aerosol generation and transport, solvent evaporation, droplet impact with consecutive spreading, and precursor decomposition. The deposition temperature is involved in all mentioned processes, except in the aerosol generation. Consequently, the substrate surface temperature is the main parameter that determines the film morphology and properties. The precursor solution is the second important process variable. Solvent, type of salt, concentration of salt, and additives influence the physical and chemical properties of the precursor solution. Therefore, structure and properties of a deposited film can be tailored by changing composition of precursor solution.

3. COMPARISON BETWEEN THE COSTS OF AN AUTOMATIZED AND A MANUAL SYSTEM

Used automatic systems can improve quality of a process due higher accuracy and repeatability or by performing the process under conditions that lead to higher quality but are not conductive for human operation. For the deposition it is need of consistent film build and coverage.

For an optimum composition and deposition temperature, the layers can be tailored by modifying the distance and angle of spraying and the pressure of the carrier gas.

Using an automatic installation it can be expected improvement in homogeneity of the layers and in the reproducibility of the process.

Costs can be reduced due to saving in laboratory cost and reduced use of some process and safety equipment. In this case for deposition process it is possible to save the material and over-spray and control of the systems reduce costs by reducing requirements and concentration of solvents for spray recovery or emission control.

Robots and automatized systems can perform tedious, repetitive tasks at greater speeds and with continuous operation. It can obtain better over-spray, less cleanup from reduced over-spray.

The manual system can produces 90 units/h and achieves an actual daily operation time of 6 h/day, employing the spray personnel a full 8 h/shift including breaks, line servicing, maintenance, cleanup and protective equipment dress up/down time. The total cost of oneh human sprayer, including salary, benefits and overhead is 1 Euro/h. Additional maintenance costs of the manual system is 100 Euro/month.

The automatic line achieves a production rate of 50 units/h, working 8 h/day. Amortizing the capital investment considering interest, investment credit depreciation and salvage values of both the new system and the retiring manual system results in an estimated equivalent annual cost of 1,000 Euro/year. The costs for service, repair and 2 skilled human operators to supervise the automatic system are expected at 0,75 Euro/h. The task of this exercise is to compare the unit production costs using the current manual system and the proposed robotic system.

Manual system:

$$\text{hourly production costs} = \frac{\text{1workers x 1Euro/h x 8h/day/worker}}{\text{6h/day}} + \\ + \frac{\text{100Euro/month x 12 months/year}}{\text{50 weeks/year x 5days/week x 6h/day}} = 2{,}13\,Euro/h \tag{1}$$

hourly production = 90 units/h

$$\text{costs/unit} = \frac{\text{hourly production cost}}{\text{hourly production}} = \frac{\text{2,13Euro/h}}{\text{90units/h}} = 0{,}024\,Euro/unit \tag{2}$$

Robotic system:

$$\text{hourly production cost} = \frac{\text{1,000Euro/year}}{\text{2,000h/year}} + \text{0,75Euro/h} = 1{,}25\,Euro/h \tag{3}$$

hourly production rate = 150 units/h

$$\text{cost/unit} = \frac{\text{hourly production cost}}{\text{hourly production rate}} = \frac{1{,}25}{\text{150units/h}} = 0{,}0083\,Euro/units \tag{4}$$

4. CONCLUSIONS

The results show that the advantages of the robotic system are very close (even better) to the manual system. In conclusion, it is hard to warrant the risk of capital investment. It is expected by using the automatic installation to increase the deposition efficiency and control, the system must be able to cover large surfaces with various geometries.

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