

# Working Principles, Advantages, and Disadvantages of IRC-REPS's Thin Films Lab Instruments

Ibraheem F. Al-Yousef<sup>1</sup>  
Supervisor: Dr. Kamal Hossain<sup>2</sup>

<sup>1</sup>Department of Physics, King Fahd University of Petroleum & Minerals (KFUPM)

<sup>2</sup>Interdisciplinary Research Center for Renewable Energy and Power Systems (IRC-REPS)

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## CONTENTS

<b>1</b>	<b>Fabrication Tools</b>	<b>3</b>
1.1	Sputtering Coater . . . . .	3
1.1.1	Working principle . . . . .	3
1.1.2	Advantages & Disadvantages . . . . .	3
1.2	Electrospinner . . . . .	3
1.2.1	Working principle . . . . .	3
1.2.2	Advantages & Disadvantages . . . . .	3
1.3	Thermal Evaporator . . . . .	4
1.3.1	Working principle . . . . .	4
1.3.2	Advantages & Disadvantages . . . . .	4
1.4	Spray Pyrolysis . . . . .	4
1.4.1	Working principle . . . . .	4
1.4.2	Advantages & Disadvantages . . . . .	4
<b>2</b>	<b>Characterization</b>	<b>5</b>
2.1	Profilometer . . . . .	5
2.1.1	Working principle . . . . .	5
2.1.2	Advantages & Disadvantages . . . . .	5
2.2	FT-IR . . . . .	5
2.2.1	Working principle . . . . .	5
2.2.2	Advantages & Disadvantages . . . . .	5
2.3	UV-Visible Spectrometer . . . . .	6
2.3.1	Working principle . . . . .	6
2.3.2	Advantages & Disadvantages . . . . .	6
2.4	Photoluminescence . . . . .	6
2.4.1	Working principle . . . . .	6
2.4.2	Advantages & Disadvantages . . . . .	6
2.5	4-Point Probe . . . . .	7
2.5.1	Working principle . . . . .	7
2.5.2	Advantages & Disadvantages . . . . .	7

<b>3</b>	<b>Treatment of Thin Films &amp; System Instruments</b>	<b>7</b>
3.1	The Furnace . . . . .	7
3.1.1	Working principle . . . . .	7
3.1.2	Advantages & Disadvantages . . . . .	7
3.2	Solar Simulator . . . . .	7
3.2.1	Working principle . . . . .	7
3.2.2	Advantages & Disadvantages . . . . .	8
3.3	Quantum Efficiency . . . . .	8
3.3.1	Working principle . . . . .	8
3.3.2	Advantages & Disadvantages . . . . .	8

# 1 FABRICATION TOOLS

## 1.1 Sputtering Coater

### 1.1.1 Working principle

Sputtering is a physical vapor deposition (PVD) technique that involves the deposition of thin films onto a substrate material. In sputtering, a target material made of the desired film material is bombarded with high energy ions from a plasma source, such as Ar ions. This ion bombardment causes the target atoms to be ejected and deposited onto the substrate as a thin film. The working principles of a sputtering coater rely on this transfer of material from the target to the substrate, which is facilitated by the high energy ions from the plasma source.

### 1.1.2 Advantages & Disadvantages

#### Advantages of sputtering coating:

- High-quality coatings: Sputtering provides high-quality, uniform and dense coatings with good adhesion to the substrate.
- Versatility: A wide range of materials can be sputter deposited, including metals, oxides, nitrides, and alloys, making it suitable for various applications.
- Controlled thickness: The thickness of the deposited film can be precisely controlled by adjusting process parameters such as ion energy and deposition time.

#### Disadvantages of sputtering coating:

- High cost: Sputtering equipment and materials can be expensive, making it a costly process for some applications.
- Complex equipment: Sputtering equipment is complex and requires skilled operators to run and maintain it, which can increase the cost of production.
- Low deposition rate: The deposition rate of sputtering is relatively low compared to other PVD techniques, making it a slower process for large scale production.

## 1.2 Electrospinner

### 1.2.1 Working principle

The working principle of an electrospinner is based on the principle of electrostatic force, which draws a liquid material into fine fibers under the influence of an electric field.

### 1.2.2 Advantages & Disadvantages

#### Advantages of electrospinner:

- High surface area-to-volume ratio: Electrospun fibers have a high surface area-to-volume ratio, which makes them useful for a variety of applications such as in energy storage and biomedical engineering.
- High porosity: Electrospun fibers have a high porosity, which makes them useful for applications such as tissue engineering and filtration.
- Tailored properties: By controlling the electrospinning parameters, the diameter, orientation, and mechanical properties of the fibers can be tailored to meet specific requirements.

#### Disadvantages of electrospinner:

- Complex setup: Electrospinning requires specialized equipment and a controlled environment, which can make it a complex process to set up and run.

- **Narrow processing window:** Electrospinning has a narrow processing window and requires precise control of various parameters to produce high quality nanofibers.
- **High production cost:** Electrospinning equipment and materials can be expensive, making it a costly process for some applications.

## 1.3 Thermal Evaporator

### 1.3.1 Working principle

The working principle of a thermal evaporator is based on heating a material to its boiling point, directing the vaporized particles towards a substrate, and condensing the particles on the substrate to form a thin film.

### 1.3.2 Advantages & Disadvantages

#### Advantages of thermal evaporator:

- **Thin film deposition:** Thermal evaporation allows for the deposition of thin films with precise thickness control, making it useful for applications such as optical coatings and solar cells.
- **Versatility:** Thermal evaporation can be used with a wide range of materials, including metals, alloys, and insulators, making it a versatile process.
- **Large scale production:** Thermal evaporation can be scaled up for large-scale production, making it useful for industrial applications.

#### Disadvantages of thermal evaporator:

- **High cost:** Thermal evaporation equipment can be expensive, making it a costly process for some applications.
- **Limited film quality:** Thermal evaporation can produce films with limited quality, such as poor adhesion and rough surface textures.
- **Vacuum requirement:** Thermal evaporation requires a high vacuum environment, which can be difficult and expensive to achieve.

## 1.4 Spray Pyrolysis

### 1.4.1 Working principle

Spray pyrolysis is a method for producing thin films of materials by spraying a solution containing precursors of the desired material onto a heated substrate. The solution is atomized into small droplets and then rapidly evaporated, leaving behind a thin deposit of the material on the substrate. The temperature and pressure conditions in the process can be controlled to influence the properties of the final film. The working principle of spray pyrolysis is based on the thermal decomposition of the precursors in the solution to form the desired material.

### 1.4.2 Advantages & Disadvantages

#### Advantages of spray pyrolysis:

- **Scalability:** Spray pyrolysis is a scalable method, which means it can be used to produce films in large quantities.
- **Versatility:** Spray pyrolysis can be used to produce films from a variety of materials, including polymers, metals, and ceramics. This makes it a versatile method for producing films for a wide range of applications.

#### Disadvantages of spray pyrolysis:

- **Uniformity:** The uniformity of the film produced by spray pyrolysis can be poor, as the droplets of solution may not evaporate evenly.

- Film thickness control: It can be challenging to control the thickness of the film produced by spray pyrolysis, as it depends on many factors such as the size of the droplets, evaporation rate, and substrate temperature.

## 2 CHARACTERIZATION

### 2.1 Profilometer

#### 2.1.1 Working principle

The working principle of a profilometer is based on the interaction between a probe and the sample surface, with the probe measuring the height of the sample surface as it is moved across the surface. The recorded data is then used to create a 3D representation of the sample surface.

#### 2.1.2 Advantages & Disadvantages

##### Advantages of a profilometer:

- High accuracy: Profilometry provides highly accurate measurements of surface roughness, profile, and contour, making it a useful tool for quality control and characterization of samples.
- Versatility: Profilometry can be used on a wide range of materials, including metals, plastics, ceramics, and composites.

##### Disadvantages of a profilometer:

- Equipment requirements: Profilometry requires specialized equipment, which can be expensive to acquire and maintain.
- Limited measurement range: Profilometry is typically limited to measuring small surface areas, and may not be suitable for large or irregularly shaped samples.

### 2.2 FT-IR

#### 2.2.1 Working principle

FT-IR (Fourier Transform Infrared Spectroscopy) is a spectroscopic technique used to determine the chemical composition and functional groups of a sample by measuring its infrared (IR) absorption spectrum. The working principle of FT-IR is based on the measurement of IR absorption by a sample, with the absorbed light being detected and used to produce a representation of the sample's IR absorption spectrum, which is then used to determine its chemical composition and functional groups.

#### 2.2.2 Advantages & Disadvantages

##### Advantages of an FT-IR:

- Versatility: FT-IR can be used to analyze a wide range of sample types, including liquids, solids, and gases.
- Non-destructive: FT-IR is a non-destructive testing method, meaning that the sample is not damaged or altered during the measurement process.
- High sensitivity: FT-IR can detect small amounts of functional groups in a sample, making it useful for trace analysis.

##### Disadvantages of an FT-IR:

- Equipment requirements: FT-IR requires specialized equipment, which can be expensive to acquire and maintain.
- Sample preparation: The sample must be prepared carefully for FT-IR analysis, and any contamination or damage to the surface can affect the accuracy of the measurement.
- Limited spectral range: FT-IR is typically limited to the mid-IR spectral range, and may not be suitable for the analysis of samples that require measurements in other spectral regions.

## 2.3 UV-Visible Spectrometer

### 2.3.1 Working principle

UV-Visible spectrometry (also known as UV-Vis spectrometry) is a technique that measures the absorption of ultraviolet (UV) and visible light by a sample. The working principle of a UV-Visible spectrometer is based on the measurement of the absorption of UV and visible light by a sample, with the absorbed light being detected and used to produce a representation of the sample's absorption spectrum, which is then used to determine its chemical composition.

### 2.3.2 Advantages & Disadvantages

#### Advantages of UV-Visible spectrometry:

- Wide applicability: UV-Visible spectrometry can be used to analyze a wide range of sample types, including liquids, solids, and gases.
- High sensitivity: UV-Visible spectrometry can detect small amounts of certain compounds in a sample, making it useful for trace analysis.
- Non-destructive: UV-Visible spectrometry is a non-destructive testing method, meaning that the sample is not damaged or altered during the measurement process.

#### Disadvantages of UV-Visible spectrometry:

- Equipment requirements: UV-Visible spectrometry requires specialized equipment, which can be expensive to acquire and maintain.
- Sample preparation: The sample must be prepared carefully for UV-Visible spectrometry analysis, and any contamination or damage to the surface can affect the accuracy of the measurement.
- Limited spectral range: UV-Visible spectrometry is typically limited to the UV and visible regions of the electromagnetic spectrum, and may not be suitable for the analysis of samples that require measurements in other spectral regions.

## 2.4 Photoluminescence

### 2.4.1 Working principle

The working principle of a photoluminescence (PL) instrument involves exciting a sample with electromagnetic radiation, such as ultraviolet (UV) or visible light, and measuring the emitted light from the sample to analyze the optical and electronic properties of the sample.

### 2.4.2 Advantages & Disadvantages

#### Advantages of photoluminescence:

- High sensitivity: PL measurement can be highly sensitive, allowing the detection of low levels of photoluminescence.
- Versatility: PL measurement can be used to study a wide range of materials, including organic and inorganic materials, polymers, and nanoparticles.

#### Disadvantages of photoluminescence:

- Low intensity: Photoluminescence is often weak compared to other optical measurements, such as fluorescence or absorption. This can limit the sensitivity of PL measurement.
- Background signal: PL measurements can be affected by background signals, such as scattered light or fluorescent light from the excitation source.

## 2.5 4-Point Probe

### 2.5.1 Working principle

The working principle of a four-point probe is based on the measurement of electrical resistance of a material using four electrical contacts. The four-point probe is commonly used to determine the resistivity of thin films, bulk materials, and other types of electrical conductors.

### 2.5.2 Advantages & Disadvantages

#### Advantages of the four-point probe :

- Simple to use: The four-point probe method is relatively simple and straightforward, making it easy to use and interpret the results.
- Non-destructive: The four-point probe method is a non-destructive testing technique, which means that it does not cause any damage to the sample under test.

#### Disadvantages of the four-point probe:

- Limitations with sample geometry: The four-point probe method can only be used to measure the resistivity of samples with a rectangular or square cross-section. Samples with more complex geometries may not be suitable for this method.
- Contact resistance: The resistance of the electrical contacts used in the four-point probe method can affect the accuracy of the results, especially when measuring low resistivity samples.

## 3 TREATMENT OF THIN FILMS & SYSTEM INSTRUMENTS

### 3.1 The Furnace

#### 3.1.1 Working principle

A furnace is a device used to heat a large space, such as a room or an industrial facility. The working principle of a furnace is based on the transfer of heat energy from a heat source to a space, through combustion, heat transfer, air circulation, and temperature control.

#### 3.1.2 Advantages & Disadvantages

##### Advantages of the furnace:

- Efficient heating: Furnaces can provide efficient and effective heating for a large space, making them a popular choice for heating homes and industrial facilities.
- Versatile fuel sources: Furnaces can be powered by a variety of fuel sources, including natural gas, propane, oil, and electricity, providing flexibility for different heating needs and locations.

##### Disadvantages of the furnace:

- High upfront cost: Furnaces can be expensive to purchase and install, requiring a significant upfront investment.
- Maintenance costs: Furnaces require regular maintenance to keep them running efficiently and safely, which can add to their long-term cost.

### 3.2 Solar Simulator

#### 3.2.1 Working principle

A solar simulator is a device used to simulate the conditions of sunlight for the purpose of testing and characterizing solar cells and other photovoltaic devices. The working principle of a solar simulator is based on the generation of intense, collimated light that mimics the spectrum and intensity of sunlight.

### 3.2.2 Advantages & Disadvantages

#### Advantages of solar simulators:

- **Controlled environment:** Solar simulators provide a controlled and repeatable environment for evaluating the performance of solar-related technologies. This allows for the optimization of device design, the improvement of manufacturing processes, and the validation of performance data.
- **Accurate measurements:** Solar simulators provide highly accurate measurements of the spectral and intensity characteristics of the light incident on the sample, which is essential for the accurate evaluation of solar-related technologies.

#### Disadvantages of solar simulators:

- **Cost:** Solar simulators can be relatively expensive, which may make them less accessible to some users.
- **Maintenance:** Solar simulators require regular maintenance, including the replacement of lamps and other components, to ensure that they remain in good working order.

## 3.3 Quantum Efficiency

### 3.3.1 Working principle

The working principle of a quantum efficiency instrument is based on the measurement of the number of photons that are absorbed, transmitted, or reflected by a sample, compared to the number of photons incident on the sample. This measurement provides information about the efficiency of the sample in converting incident photons into electrons, which is known as the quantum efficiency.

### 3.3.2 Advantages & Disadvantages

#### Advantages of quantum efficiency:

- **High precision:** Quantum efficiency instruments offer high precision measurements, which enables researchers and engineers to make accurate and reliable evaluations of the performance of photovoltaic devices and optical detectors.
- **Broad applicability:** Quantum efficiency instruments can be used to measure the performance of a wide range of materials, including semiconductors, metals, and organic materials, making them a versatile tool for a wide range of applications.

#### Disadvantages of quantum efficiency:

- **Cost:** Quantum efficiency instruments can be expensive, which may limit their accessibility for smaller research and development organizations or academic institutions.
- **Complexity:** The measurement of quantum efficiency requires a detailed understanding of the underlying physics and technology, as well as a well-calibrated instrument. This complexity may present a barrier to entry for researchers who are not familiar with the field.