



LOW-COST SENSOR FABRICATION

Thin-film fabrication

Abstract: We have developed in-house spin-coating and drop casting techniques for thin-film fabrication for (1) Polymer characterization (2) Thin-film sensors. These are low-cost and simple. Here design of a low cost, portable spin-coater along with discussion of drop casting technique is presented.

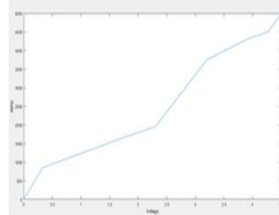
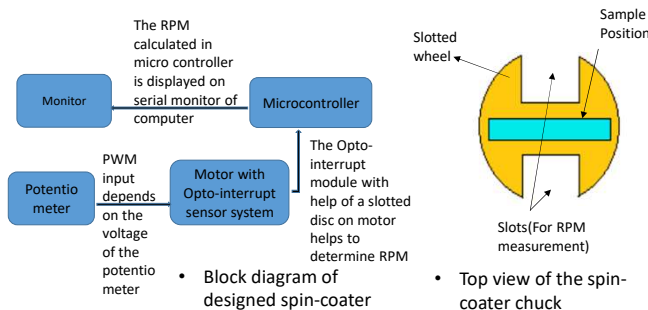
Objective:

1. Design of a **speed controllable and observable spin-coater** is presented.
2. Discussion of **drop-casting** technique.

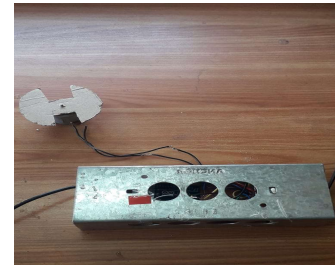
Method:

Spin-coater: Key features of design and performance are listed here

- **Speed control** is achieved via **varying motor PWM** (Pulse Width Modulation). The PW given is changed by **potentiometer knob** (regulator like fashion)
- **Speed characterization:** Characterization was done using **AtMega328P** and an **Opto-interrupt sensor module** with output displayed on **monitor**.
- **Safety and portability** are ensured by **isolating electronics in a shielded box** and providing **protective cover to coater chuck**.
- The system is **bench-top and portable**. **Costs < Rs. 2000** and easy to replicate.



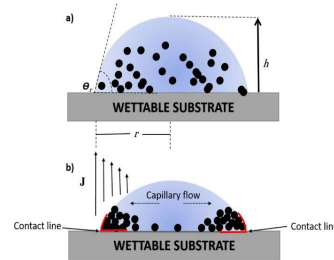
• RPM of Motor vs Voltage.



• Designed spin-coater with electronics in a shielded box and motor outside

Drop casting: In this process, a few μL of solution (solute + solvent) is deposited on the surface of clean substrate. The thin-film formed after evaporation (at Room Temperature or thermally assisted) of the solvent, leaving behind thin-film of solute. The main problem with drop-casting is **Coffee ring effect (CRE)** (forming a ring-like structure, after evaporation). This compromises the film quality, as most of the solute is present near the ring formed, thus creating huge non-uniformity.

Origin of CRE-The rate of evaporation is more at the edges of the drop (due to more area of exposure to surroundings than center), thus causing a radially outward flow of solvent towards edges.



• Coffee Ring Effect (From [1] under Creative Commons License)

Methods to reduce CRE:

- **Making substrate super-Hydrophobic-** This leads to **slipping of solvent** over substrate at edges, thus leading to uniform deposition
- **Electrowetting-AC voltage of high frequencies is passed through the drop,** which causes solute to disperse more evenly.
- **Acoustics-** The particle overcomes the capillary drag due to **high energy SAW** (Surface Acoustic wave) and settles in the **nodal regions** of the standing wave formed. [1]

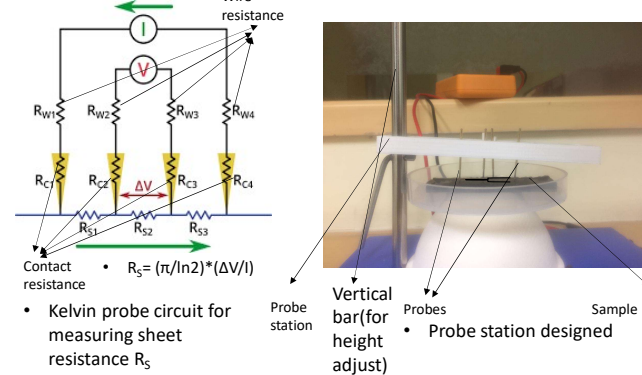
Thin film characterization

Abstract: To characterize electrical conductance (or resistance) of the thin-film, we developed a **Probe station for measuring resistance** of films with area less than 1cm^2 by using Kelvin Probe method. Probe stations used for probing micro devices are costly (min 0.5 lakhs). Through this probe station, we can make measurements on different films using simple source meter (like Keithley 2400) without need of any other equipment.

Objective: Develop a height and width adjustable solution for Kelvin Probe technique.

Method:

We **3D printed** a probe support which allows placement of probes at **different distances** between them (Minimum distance = 5mm). We can also **adjust the height** of the supporting bar for better contact with the sample. (Mincost = Rs500)



Thus, the proposed design can effectively be used for different spacing between probes (implying **different thicknesses of samples can be characterized**)

References:

[1] Archana Kaliyaraj Selva Kumar, Yifei Zhang, Danlei Li, Richard G. Compton, A mini-review: How reliable is the drop casting technique?, Electrochemistry Communications, Volume 121, 2020, 106867, ISSN 1388-2481, DOI = <https://doi.org/10.1016/j.elecom.2020.106867>.