

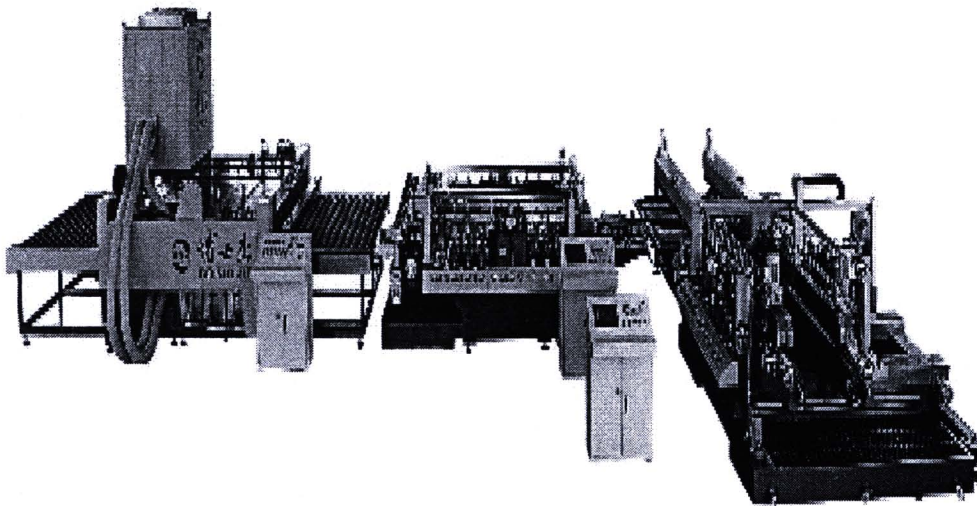
## CHAPTER III

### METHODOLOGY

#### List of Equipment and Instrument

Following equipment and instrument are required for production and verification of the TCO glass specifications:

1. Glass preparation equipment
  2. TCO coating line
  3. Four-point probe
  4. Gaertner ellipsometer
- 1. Glass preparation equipment consists of:**



**Figure 44 Glass Edge Seamer and Washing Equipment**

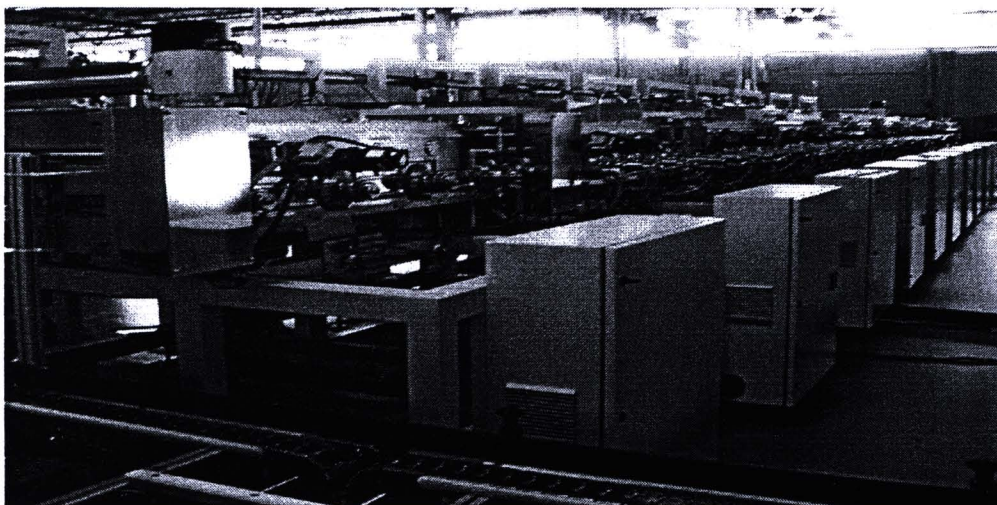
#### 1.1 Soda-lime glass edge seamer

To avoid personal injury during the production and installation, sharp edges at all four sides of the soda-lime glass sheet must be eliminated or seamed in the seaming equipment before sending for cleaning.

### 1.2 Washing machine

Before coating of  $\text{SiO}_2$  and  $\text{SnO}_2$  layers, the glass surface must be properly cleaned and free of stain, fat or grease, impurity and foreign particles from earlier process.

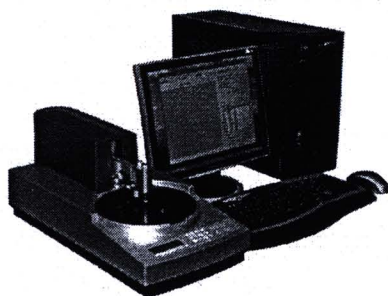
### 2. TCO Glass Coating Machine



**Figure 45 TCO Glass Coating Machine now installed at Bangkok Solar**

This TCO Glass coating machine (with in-line sputtering method) has the throughput capacity to produce 150,000 pieces TCO glass per year. Indium-doped Tin Oxide (ITO) and  $\text{SiO}_2$  targets are used for depositing of the transparent conductive oxide layer;  $\text{SnO}_2$  and diffusion barrier;  $\text{SiO}_2$  on 3.2 mm thick and 635x1,250 mm soda-lime glass sheet according to the recipe provided by the technology/equipment supplier. The in-house TCO glasses produced from this equipment will then be sampling tested and measured of the required parameters i.e. sheet resistance, uniformity and transparency.

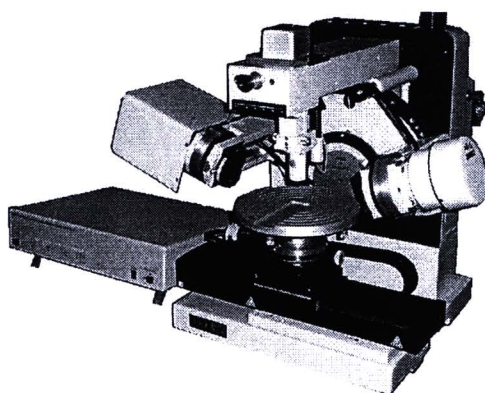
### 3. Four-point Probe [13, 14]



**Figure 46 Four-point Probe for Sheet Resistance Measurement**

The four-point probe technique is one of the most common methods for measuring the resistivity. This method is an electrical measuring technique that uses separate pairs of current-carrying and voltage sensing electrodes to make more accurate measurement than the traditional two-terminals. Today the four-point probe technique is widely used in the semiconductor industry to monitor the production process. The measurement of sheet resistance of the thin-film will be made at 5-9 specified locations at 20-30 mm from 4 rims of the sample. The measured resistance required for this In-house TCO glass shall be approx. 10-15 ohm/square. The data obtained from this measurement will also define the uniformity or thickness variation of the coated layers on the sample which shall be within +/-10% ranges. Evaluation of film properties as per Appendix 2.

#### **4. Gaertner Ellipsometer [15]**



**Figure 47 Gaertner Ellipsometer for Light Transmission Measurement**

Ellipsometry is a versatile and powerful optical technique for investigation of the dielectric properties of thin films. It measures the change of polarization upon reflection and transmission. With this instrument, transmittance which is the fraction of incident light at a specified wavelength (at 550 nm for this study) that passes through a sample can be measured. For this experiment, total transmission through the coated layers (excluding the glass media) shall be more than 80%.

### **Method of Experiment**

Produce In-house TCO glass in the TCO coating line installed at Bangkok Solar Co.,Ltd. using standard soda-lime 3.2 mm glass sheet as raw material.

### **Experiment Set-up**

The equipment for the experiment is already set-up at Bangkok Solar as per the photo shown above and is ready for experiment and verification of the concept.

### **Data Collection Method**

The samples of In-house TCO glass to be tested and data collected during the commissioning test by the equipment manufacturer of the TCO glass coating line at Bangkok Solar. After that production test to be conducted and tested by the production team. Following parameters will be measured and collected under both periods:

1. Sheet resistance shall be around 12-15 Ohm/square
2. Uniformity or thickness variation of the layers shall be within +/- 10%
3. Optical transmission in 400-800 nm regions shall be better than 80%