

PHOTOVOLTAIC – MATERIALS, CELLS AND DEVICES

CHALLENGES		SOLUTIONS
Chemical Analysis /Spectroscopy	<ul style="list-style-type: none"> ▪ Detection and quantification of impurities ▪ Encapsulant studies ▪ Characterise encapsulates, degradation of encapsulates ▪ Chemical and thermal analysis of organic material ▪ Qualitative chemical measurements ▪ Optical transmission/reflection ▪ Surface height/roughness; manufacturing accuracy 	<ul style="list-style-type: none"> ✓ Fourier Transform Infrared Analysis ✓ Gel Permeation Chromatography ✓ Differential Scanning Calorimetry ✓ Thermal Gravimetric Analysis ✓ Wet Chemical Analysis ✓ UV-Visible-IR optics spectrometer ✓ Atomic Force Microscope
Device / Internal Analysis	<ul style="list-style-type: none"> ▪ Visible inspection of defects/failures ▪ Large area cross section cutting, large area patterning ▪ Removal of organic compounds/surface cleaning ▪ Device characterisation ▪ Long duration testing, calibrated solar cell at AM1.5G ▪ Cross sectional analysis/imaging of <100nm defects ▪ Multiple low noise electrical measurements ▪ Depth profiling, identifying contaminants/impurities ▪ Surface cleaning, surface mapping of elements 	<ul style="list-style-type: none"> ✓ High Magnification Optical Microscopes ✓ Laser Isolation/patterning/cleaning equipment ✓ Plasma Etcher ✓ Probe Stations for Device Characterisation ✓ Class 'A' solar simulator and light soakers ✓ Focussed Ion Beam/SEM ✓ Switch Matrix ✓ TOF-SIMS
Electrical / Electronic Test	<ul style="list-style-type: none"> ▪ Low noise IV measurements ▪ Series/parallel resistance calculation, capacitance, diode factor, minority carrier lifetime, acceptor impurities, density and depletion layer charge density ▪ Automated, multiple low noise electrical measurements 	<ul style="list-style-type: none"> ✓ Agilent Femto-Amp resolution parameter analysers ✓ RLC bridges impedance measurements ✓ Automated Test Equipment
Environmental Testing	<ul style="list-style-type: none"> ▪ Outdoor monitoring trials ▪ Outdoor monitoring trials ▪ Accelerated tests ▪ Full module testing ▪ Accelerated weathering & UV degradation ▪ Testing for delamination, yellowing, cracking, colour cx 	<ul style="list-style-type: none"> ✓ Outdoor test rigs for solar modules ✓ Weather station and irradiance sensor ✓ Environmental Chambers ✓ Light soaking ✓ AM1.5G solar simulator
Electron Microscopy / Surface Analysis	<ul style="list-style-type: none"> ▪ External visual inspection for cracks/failures/defects ▪ Elemental analysis ▪ Surface roughness of optical coatings ▪ Metal corrosion ▪ Identification of phase ▪ Optical constants, non-destructive change to optical properties ▪ Cross sectional analysis, failure analysis 	<ul style="list-style-type: none"> ✓ Field Emission Scanning Electron Microscopy ✓ Energy Dispersive X-ray Spectroscopy ✓ Atomic Force Microscopy ✓ Kelvin probe microscopy ✓ X-ray Diffraction ✓ Ellipsometry ✓ Focussed Ion Beam (via partner)
Materials Processing	<ul style="list-style-type: none"> ▪ Solar cell fabrication ▪ Vacuum annealing solar cells ▪ PV fabrication (Active layers/contacts) ▪ Electrical contact/dielectric/AR coating ▪ Electrical contact/dielectric/AR coating ▪ Step heights ▪ Calibration of TOF-Sims 	<ul style="list-style-type: none"> ✓ Vacuum Furnaces up to 600° C ✓ Photolithography ✓ 3-source sputter coater ✓ Electron Beam deposition ✓ Thermal evaporation of metals/organic materials ✓ Class 1000 cleanroom ✓ Atomic Force Microscopy
Non-Destructive Analysis	<ul style="list-style-type: none"> ▪ Surface roughness of optical coatings ▪ Metal corrosion ▪ Identification of phase 	<ul style="list-style-type: none"> ✓ Probe station, surface analysis equipment - AFM ✓ Probe station, surface analysis equipment - KFM ✓ Probe station, surface analysis equipment - XRD
Electrostatic Testing	<ul style="list-style-type: none"> ▪ Surface resistivity measurement ▪ Charge Decay monitoring ▪ Field Meter measurement ▪ Conduction to ground monitoring ▪ Powder coating test set 	<ul style="list-style-type: none"> ✓ Surface resistivity measurement ✓ Charge Decay monitoring ✓ Field Meter measurement ✓ Conduction to ground monitoring ✓ Powder coating test set
Software	<ul style="list-style-type: none"> ▪ Estimations of solar farm performance for fault identification 	<ul style="list-style-type: none"> ✓ Specialised FMEA software package ✓ PV Sol installer software ✓ High Performance Computing access