DEVELOPMENT OF MULTI-FUNCTIONAL PASSIVE COOLING SELF-CLEANING-SELF-DISINFECTION FILM IN GREENHOUSES

PROJECT OBJECTIVES

This project aims to study the performance of various multi-layered films used in the windows of greenhouses by using magnetron sputtering film deposition technique. The ideal films to be used for greenhouses should have high UV filtration, low near-infrared radiation (NIR) transmittivity, good light diffusion and self-cleaning-self-disinfection properties.

PROJECT SUMMARY

As Singapore moves towards self-sustainability in various food commodities, urban farming using greenhouses will play an increasing important role in this aspect. However, to achieve self-sustainability, the yield efficiency of greenhouses becomes paramount in land-scarce Singapore. To increase the yield efficiency of greenhouses, it is necessary that the photosynthetically active radiation (PAR, 400–700 nm), which is crucial for plant growth and photosynthesis, is transmitted into the greenhouses, while the NIR that causes heat loads, is reflected away.

The project compares the performance of different multi-layered films by using magnetron sputtering film deposition technique using titanium dioxide (TiO2), copper oxide (CuOx), silicon dioxide (SiO2) and silicon (Si) onto transparent acrylic. Single, bilayer and 3-layer films are investigated by varying the sputtering conditions (RF power, gas type, gas flow and duration). Film properties such as surface roughness, selective wavelength absorption and hydrophobicity nature are characterised using Atomic Force Microscopy, Surface profiler, UV-Vis spectroscopy, PAR sensor and Optical tensiometers. These multi-layered films were tested for bacteria and fungus cultivation to assess the effectiveness of anti-bacterial properties. They were also tested on their effectiveness in reducing the internal temperature of a greenhouse.

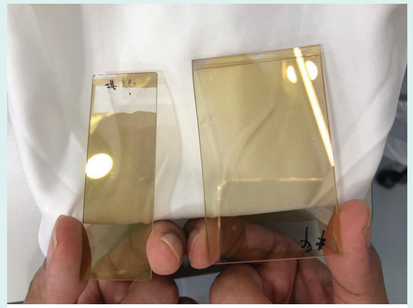
PROJECT OUTCOMES

The team's preliminary study found that the optimum multi-layered film comprises:

LAYER	FILM	SPUTTERING CONDITIONS (RF Power, Gas Type and Gas Flow)
1st Layer (outermost)	Titanium Oxide (TiO2)	300 W, Argon 50 sccm
2nd Layer	Copper Oxide (CuOx)	200 W, Argon/Oxygen 50/5 sccm
3rd Layer	Silicon (Si)	200 W and Argon 50 sccm

The thickness of this optimal film is around 180 nm. It has a high PAR transmission (74% of red and 50% of blue), a lower NIR transmission of 86% and a low UV transmission of 16%. This film also reduces bacteria count by up to nine times compared to the uncoated sample. Compared to the uncoated sample, the use of this film is estimated to reduce the greenhouse temperature by about 3°C.

MULTI-LAYERED FILMS



Left: Films deposited on glass substrate
Right: Films deposited on acrylic substrate

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