Project 1 - Nanotechnology for optical spectroscopy

Infrared spectroscopy is finding increasing application in many industries including, pharmaceuticals, agriculture, viticulture, remote sensing, and defence. IR spectroscopy has successfully been demonstrated to detect a range of substances, including water, nitrogen and carbon in soil, protein in wheat, and pollution in the atmosphere. Deployments of spectroscopy range from lab-based instruments for high-precision applications, to semi-miniaturised instruments for portable applications, to multi- and hyperspectral imaging instruments for airborne remote-sensing applications. In the airborne arena, unmanned aerial vehicle (UAV) based deployments are looking increasingly attractive. The main limiting factors to more pervasive deployment of infrared spectroscopy are presently, the capital and maintenance costs of the spectroscopy equipment; size and portability; sensitivity to vibration and shocks; and calibration maintenance. Particularly for application in Agriculture and the minerals industry, the need for low cost, small and rugged spectroscopy instruments is immense.

The Microelectronics research group (MRG) is Australia's leading research group on micro machines (MEMS). A key development from MRG is a suite of nanometer-scale thin-film spectrometer technologies, which stands to address all the requirements to turn infrared spectroscopy into a everyday tool. Just imagine a spectrometer in your mobile phone that can tell you if your fruit is ripe enough or your milk is turning sour. The overall aim of this project will be to assess and develop thin-film spectrometer technologies for various applications. While these projects are highly challenging and can be immensely rewarding.

Sub-projects (student positions): 2-4

Project 1.1 (Maths/EE/CS): Spectral analysis of water stress in plants

This sub-project will assess suitability of thin-film spectrometer technologies for water stress detection in plants. The key task of this work will be to (1) measure optical transmission spectra of leaves; (2) identify key spectral features associated with water in the leaves; and (3) evaluate variability between different leaves and different types of plants. This sub-project will involve a host of measurements on a bench-top spectrometer and data analysis to identify spectral features. This project will then assess suitability of these spectral features for identification by a portable thin-film spectral analysis tool.
Project 1.2 (EE/CS): A portable system for thin-film spectral analysis
-----------------------------------------------------------------------------------
This sub-project will develop a portable transmission spectrometry system that will use the information generated in Project 1.1. It will pass light through a thin sample, such as a leaf, and measure calibrated optical transmission through the sample. A capable student should be able to complete this development, incorporating a Bluetooth transceiver, and develop an app for a mobile phone to read data from the unit.

Project 1.3 (EE): An imaging thin-film spectrometer
-----------------------------------------------------------------------------------
With unmanned aerial vehicles (UAVs - drones) becoming cheaply available, the potential for using imaging spectroscopy for unmanned aerial analysis is becoming highly attractive. Drones can be used in agriculture to detect weeds, or assess water or nutrient requirements of crops. Fertilizer/water/herbicide can then be applied as required in a localised region, to prevent wastage. Such "Intelligent agriculture" is the future of farming and this technology stands to play a major part. This sub-project will be demonstrating the first prototype of a low-cost imaging spectrometer for such applications. While UAV deployment is envisaged for the second prototype, this sub-project will lay the groundwork for allowing the next phase to be successful.

Project 1.4 (EE/CS): A portable MEMS spectrometer system
-----------------------------------------------------------------------------------
This sub-project will incorporate our MEMS spectrometer into a fully portable spectrometer unit. This portable spectrometer unit needs to supply light to a sample and measure an entire optical spectrum using the MEMS micro spectrometer technology. The system will need to provide appropriate drive signals to the micro spectrometer, measure the spectrum, and provide the data to a mobile phone via a bluetooth interface.