Abstracts on the CPFR Presentations:

Presentation #1: ***III-V Semiconductor Photonic Device Integration on Group IV Substrates***

Recent popularity of small computing devices combined with internet growth and the diminishing size and cost of sensors lead to the possibility of making very small systems which incorporate elements of autonomous sensing, computing and a communication system all on a chip of ~1 mm3. This type of system would look like a speck of dust or a mote. Since large quantities of devices could be made and would be designed to communicate with each other, this networked system could facilitate new methods of interacting with the environment; providing more information from more places less intrusively. Some possible applications could be providing interfaces for the disabled or monitoring environmental and structural conditions that affect crops, livestock or areas with contaminants. When developing smaller sized motes, energy consumption is one of the primary drivers in technology selection. To realize such small systems, an option is to look at optical communications using semiconductor lasers and diode receivers which consume 1 nanoJoule per bit and 0.1 nanoJoule per bit respectively. Two of the big challenges for these devices are the ability to pack all the functionality in a very small footprint and having a source of power large enough to support all device functions. This project aims to determine if the high-efficiency solar cell devices developed by Cyrium Technologies for space and solar farm applications could be employed to power micro-sized motes. Could these solar cells deliver enough power to enable operation of the motes? Can the materials used be integrated in motes? Analysis of power requirements and technologies will be presented in addition to early results on solar cell coatings and metal deposition.

Presentation #2: ***Fabrication of Surface Plasmon Waveguides on Membranes***

Waveguides and integrated components for long-range surface plasmon-polaritons are described. The waveguides consist of a thin (20 - 35 nm) narrow (~5 mm) Au/Cr stripe, on an ultra-thin large-area (~1 mm2) free-standing dielectric membrane clamped around its perimeter to an underlying Si substrate, and the integrated components consist of structures such as Mach-Zehnder interferometers and couplers. The waveguide and components are dimensioned such that they propagate long-range surface plasmon-polariton waves in a vacuum (air) or H2O background. Progress toward the fabrication of such structures will be described along with the fabrication process flow adopted. Details on some of the specific process steps are given. Physical characterisation was conducted on structures having undergone intermediate process steps and characterisation results are given and discussed.

Presentation #3: ***CPFR Project Title: CMOS Image Sensors***

CMOS image sensors are used in many applications such as biomedical, security and consumer electronics. Fabrication is relatively cheap (compared to CCD –based image sensors) because the CMOS image sensor device along with peripheral control and image processing electronics can be integrated on the same silicon chip. CMOS image sensors (compared to CCD) suffer from degraded performance: noisy image under low-light conditions and blurring. Also for some critical applications power consumption needs to be reduced. This project focuses on a research program to achieve performance improvements in these areas, in this presentation new pixel design and image resolution enhancement approaches will be discussed.

Presentation #4: ***Photonic Quasi-Crystal Based Integrated Optical Resonator Coupler***

To date most of the scientific research in photonic crystal structures focused on periodic structures that contain translational symmetry where solid-state theory can be used for the analysis of the photonic crystals, and standard semiconductor fabrication techniques can be used for building planar photonic crystal structures. Recently it has been shown that rotationally symmetric intricate dielectric structures can also display a photonic bandgap. These structures are known as photonic quasi-crystals (PQX) and display aperiodicity similar to the aperiodic semiconductor materials recently discovered. In addition to the bandgap features of the quasi-crystal, PQX structures have inherent defect states coupled to the central pivot point of the rotationally symmetric pattern. Research is underway worldwide in order to exploit these new photonic aperiodic materials. This CPFR research project involves the design of PQX structures employing dielectric materials to enable the bandgap to be situated in the wavelength range around 1.55 microns. In this talk we will discuss design considerations of PQX devices.

Presentation #5: ***Optical Waveguide-Based Microcytometer***

Microcytometer (microfluidic-based flow cytometer) has attracted much attention recently due to its excellent features such as low-cost and small size. However, despite advances in the development of the microfludic components, the optical detection systems involved in current microcytometers are mainly based on complex and expensive free space optics. As a result, it still lacks the easy operation, portability and low cost required for widespread use. In the project, we are trying to integrate planar optical waveguides into the microcytometry devices to replace the free-space optics, and thus avoid optical alignment issues, making the system vibration/shock insensitive and further reducing its cost and size. In the presentation, progress on design and fabrication of a novel microcytometer will be reported. Advantages of a novel “T” structure design will be explained. Simulation results of the “T” structure will be detailed. Achievements and issues on device processing will be introduced.

Presentation #6: ***Fabrication of Erbium-doped silicon-rich planar waveguide devices***

To realize full color light emission from Si-based materials, rare-earth (Er, Ce, Tb and Eu) doped silicon oxides (oxygen-rich or silicon-rich) were deposited by electron cyclotron resonance plasma enhanced chemical vapour deposition (ECR-PECVD) at McMaster University. Silicon nanocrystals (Si-ncs) were formed in the silicon-rich films during certain annealing processes. High concentration in-situ rare-earth incorporation was confirmed by Rutherford backscattering spectroscopy (RBS).The film composition space generated from deposition parameters including microwave power, precursor gas flow and rare-earth precursor temperature were mapped. The emission properties of the films were analyzed through photoluminescence (PL) spectroscopy. The rare-earth related PL intensity was optimized by varying film compositions and post-deposition annealing conditions. The correlation between PL properties and film structures has been elucidated through high resolution transmission electron microscopy (HR-TEM) and Fourier infra-red spectroscopy (FTIR). Possible applications of such materials for waveguides and waveguide amplifiers will be discussed.