CUDOS

The Centre for Ultrahigh bandwidth Devices for Optical Systems (CUDOS)

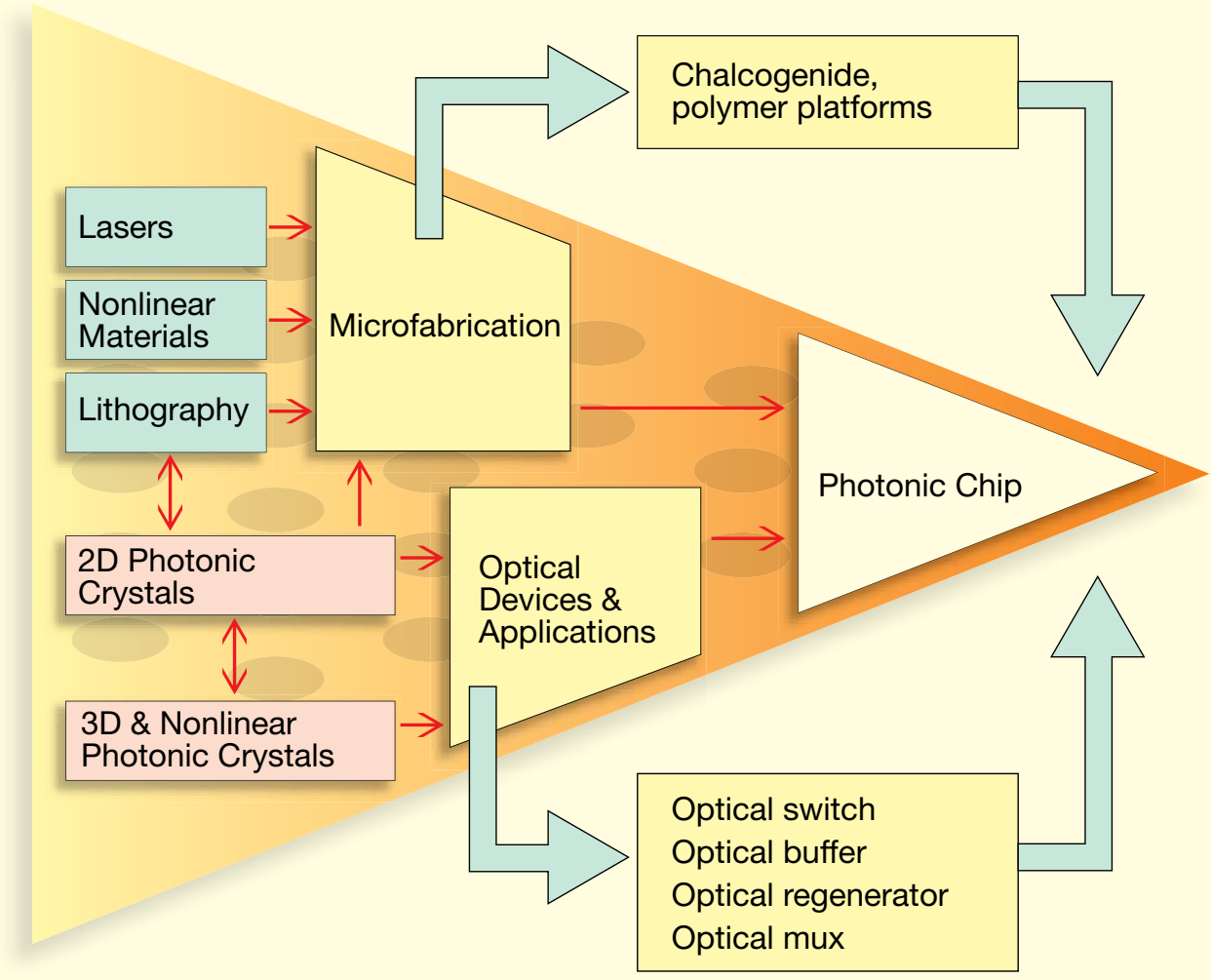
2005 Annual Report

Flagship Projects – Introduction

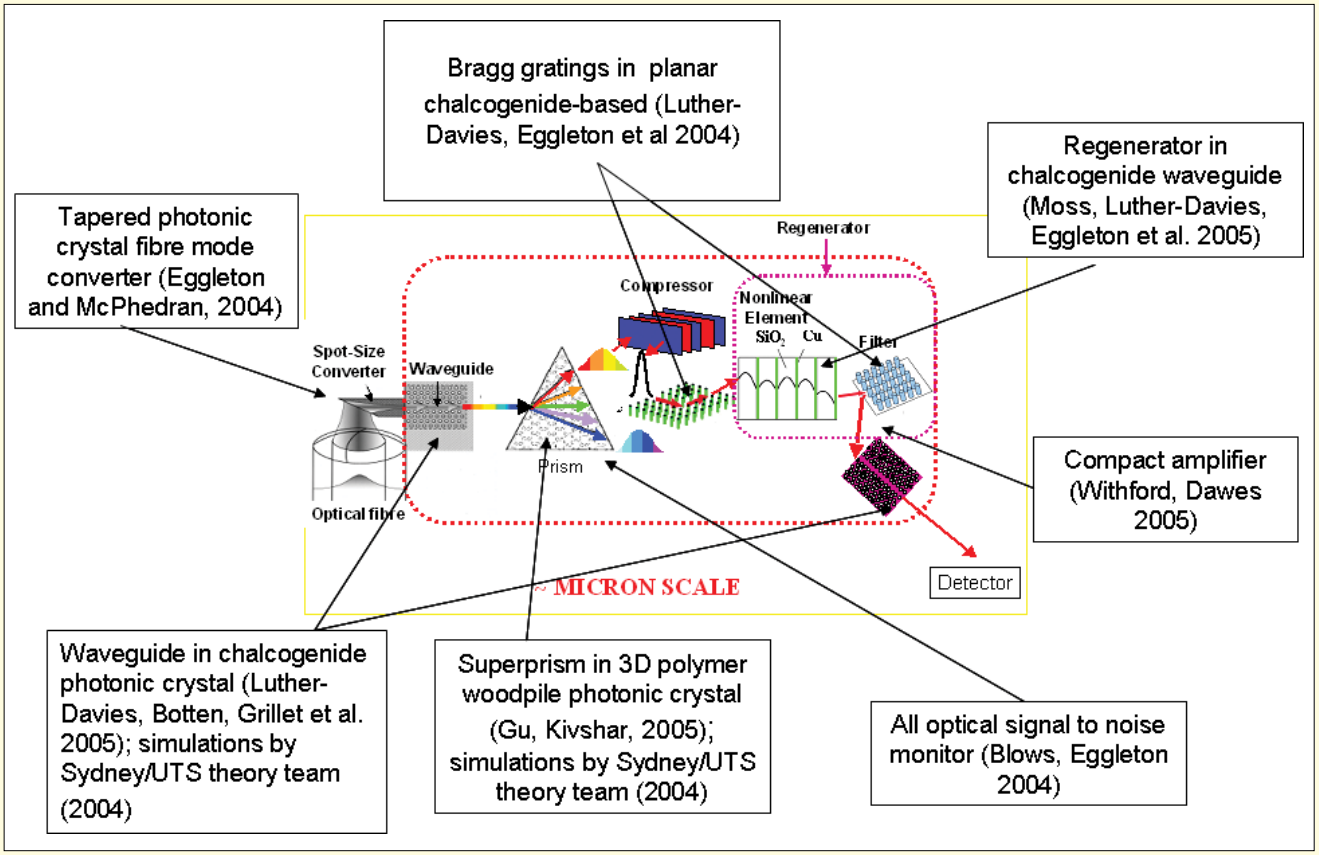
The CUDOS research plan is, in broad terms, very much about establishing key science and technology platforms during the early years of operation, and building on these during the latter years to demonstrate key aspects of all-optical processing on a photonic integrated circuit. In late 2004 at a planning meeting, the Centre's Chief Investigators and Project Leaders recognized that these platforms were sufficiently well-established to proceed to the stage of identifying 'Flagship' projects from the suite of CUDOS research activities. These would act as highlighted examples of our progress towards our key strategic goal. The flagships would combine leading edge science with the potential for high community impact, and through their scale would involve several collaborating universities.

The flagship projects that were chosen at that meeting reflect our primary mission, which is to develop photonic technologies underpinning the next generation of optical communications systems, as well as highlighting our unique research achievements in the field of photonics. Since our Centre commenced operation in 2003, it is becoming more and more accepted that the next generation of optical networks will be built around the widespread deployment of photonic integrated circuits, allowing a shift from optoelectronic to all-optical processing ("transparent optical networks"). Accordingly, three of our Flagship projects reflect this exciting trend, while the fourth lays the science fundamentals for even more exciting developments in this area. All four projects draw heavily upon, and indeed synthesize, the outputs across a number of our research activities. We are excited that our Flagships are all demonstrating excellent progress against their strategic goals, and that the innovative research intrinsic to these activities is being published in the most highly-cited journals in our field.

Developments in each flagship project over the past twelve months have been most exciting, and a full day at the CUDOS Workshop in October 2005 was dedicated to presentations on these projects. The projects are briefly described below, with more substantial descriptions on the following pages.



▲ **Flagships integrate and build on the activities within our research projects.**



▲ **The CUDOS program to date has focused on demonstrating individual functionalities that ultimately would appear in a photonic integrated circuit. Those demonstrated include efficient conversion from single-mode fiber, waveguides and microcavities in photonic crystals, demultiplexing and beam steering using photonic crystals, dispersion control and optical filtering using Bragg gratings, optical performance monitoring and all-optical regeneration and optical amplification.**

- **Optical Buffering:** Buffering in an integrated circuit refers to the delay or even temporary storage of data signals for re-timing and clock synchronization operations. It will be as important in a PIC as it is in present day electronic circuits, but quite different, since photons are notoriously difficult to store! Nevertheless, they can be slowed down significantly – and controllably. Our approach to developing an optical buffer is based around the use of a photonic crystal in a nonlinear waveguide through which the optical pulse travels. By carefully tuning the dispersion properties of the grating, we have succeeded in converting an optical pulse into a slowly-propagating optical soliton inside the grating, with pulse delays greater than the width of the pulse itself and equivalent to world's best performance.
- **Optical regenerator on a PIC:** The realization of a compact optical regenerator, integrated onto a PIC with other optical functions, was identified as a key technology enabler for transparent optical networks by a National Science Foundation planning workshop in 2005[1]. Regeneration means re-shaping, re-amplifying and possibly re-timing a degraded optical signal. The CUDOS approach, which is unique internationally, is based on a compact photonic system fabricated in a thin film of highly nonlinear chalcogenide glass deposited on a planar substrate. During 2005 the first prototypes were tested, and a nonlinear transfer function (input to output) was measured. Our report details the encouraging progress made to date.
- **Optical Switch in a PIC:** Switching, the use of a control to turn a signal on or off, is a fundamental operation in any network. In a transparent optical network, the switching must be done optically, in other words light is used to switch the optical carrier on or off. The requirement for nonlinearity inherent in switching is achieved, once again, by building a prototype in a chalcogenide thin film and taking advantage of the nonlinear properties of the material. One approach, switching the light in or out of a resonant cavity, is being investigated. The theoretical performance of this system is well understood, but two substantial experimental challenges, that of building a photonic crystal with a resonant cavity and actually coupling the light into the resonant cavity, were solved by our research team late last year. These achievements lay the platform for substantial progress in 2006.
- **Three dimensional photonic crystals**: Three dimensional photonic crystals offer the opportunity to explore a number of concepts intrinsic to these materials. In our project, based on innovative experimental techniques to fabricate photonic crystals from polymer material, we have investigated, and demonstrated, a range of optical phenomena that exemplify the unique properties of photonic crystals. These include the "superprism", an ultra-high dispersion effect that may find application as a compact multiplexer in a PIC and a 3D photonic crystal-based etalon.

[1] Report of NSF Workshop and Planning Grant on "Mapping a Future for Optical Networking and Communications", July 2005 (http://www.geni.net/nsf-opt-200507.pdf).