The Centre for Ultrahigh Bandwidth Devices for Optical Systems (CUDOS) is aiming to realise the vision of the so-called “Photonic chip”, the optical equivalent to a microprocessor integrated circuit (IC). This goal depends on the ability to miniaturise and integrate photonic components into a single chip and thus metamaterials, in particular photonic crystal like structures, play a key-role in the research program. Our group at Macquarie University is focussing on developing fabrication techniques for these devices.

In recent years the field of direct write optical waveguide fabrication has expanded rapidly due to the versatile and flexible nature of this technique. By translating a tightly focused femtosecond laser beam through a dielectric medium, a region of refractive index change can be generated at the beam focus. Glasses of various compositions are the most common media used in this technique and the localised change in refractive index is typically positive, thus creating a waveguide analogous to the common step-index optical fibre. Using this technique we have fabricated highly symmetric optical waveguide structures in passive, active and highly nonlinear dielectric media. Beyond it, we will review our activities towards the fabrication of a single-chip all-optical integrated waveguide amplifier.

In addition, we have been developing the technique of point-by-point inscription of fibre-Bragg gratings (FBGs) using a low-repetition rate (1 kHz) femtosecond laser for the application to passive and active optical fibres.

We will present our capabilities for writing arbitrary gratings in virtually any kind of optical fibre and will demonstrate our ability to write 1st order gratings at a wavelength of 1μm, consistent with a periodic modulation of the refractive index with a period of only 700 nm.

In a natural combination of these fields of work we will report on the fabrication of Bragg grating structures in direct femtosecond laser written optical waveguides in passive and active media [1]. Such structures provide the opportunity to create a new range of photonic devices that, as examples, include wavelength division multiplexed (WDM) channel separators and micro-laser components.

Furthermore, we will show that by increasing the femtosecond laser peak intensity slightly above the damage threshold, sub-wavelength structuring of dielectric surfaces is feasible. Due to the multi-photon nature of the ablation process, the achievable resolution is strongly dependent on the band-gap of the material. We will present our activities in the development of a novel femtosecond laser source [2], which allows unprecedented resolution and is perfectly suited to rapid prototyping of large area 2-D photonic band-gap structures.

References: