# Performance Studies of Directly Written High Power Monolithic Ytterbium Waveguide Oscillators

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The use of a scanned femtosecond laser focus to create optical waveguide devices is an established and powerful technique with applications in telecommunications, biotechnology, sensing and quantum information. Using a sub-surface focussed femtosecond laser, a dielectric material can be modified at a highly localised point without surrounding material modification. By controlling the laser-interaction parameters the localised change can result in a permanent positive change in the refractive index of the material thereby forming an optical waveguide device [1].

Various 2D and 3D optical waveguide devices (bulk glass analogues of optical fibres) with different characteristics have been fabricated in many transparent materials [2]. Not only can this direct-write technique be carried out rapidly, it is readily compatible with existing fibre systems, it does not require a lithographic mask and it can be conducted in a regular laboratory environment with the minimum of sample preparation.

At the CUDOS at Macquarie we have successfully used this technique to fabricate monolithic distributed feedback (DFB) waveguide oscillator devices (Fig. 1(a)) in doped phosphate glasses at arbitrary laser wavelengths [3,4]. In our most recent experiments we fabricated an efficient, high-power waveguide laser (WGL) operating at 1.032 μm in Ytterbium-doped phosphate glass with single-ended output powers over 100 mW. The pump power threshold was approximately 115 mW and the optical efficiency was over 17% (Fig. 1(b)). This WGL typically operated on two degenerate polarisation modes but could be restricted to a single-polarisation mode through the use of polarised pump light.

Such a device represents the first demonstration of an efficient high power monolithic WGL created entirely using the femtosecond laser direct-write technique. Given the flexibility of the femtosecond laser direct-write technique for creating structures on a per pulse basis, there also exists the potential to develop novel DFB designs to create multiple laser output lines. In this paper a review of our ongoing activities in monolithic WGL fabrication will be presented. In particular, we will present stability studies of these lasers and demonstrate the ability to control the phase shift position created within the DFB structure thus enabling bi- or uni-directional laser operation.

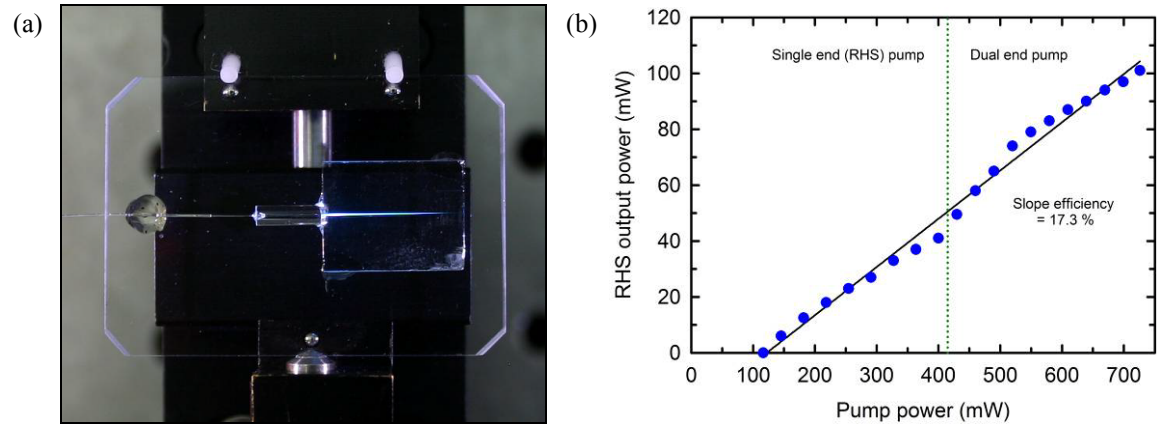


Fig. 1. (a) A pigtailed waveguide oscillator device operating at 1.032 μm fabricated in Ytterbium-doped phosphate glass using the femtosecond laser direct-write technique and its (b) laser output power as a function of pump power for single and dual end pump geometries.

## References

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978-1-4244-4080-1/09/$25.00 