Development of a broadband tunable fibre laser

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Abstract
The purpose of this thesis was the investigation and development of a fibre laser with a broad tuning range. Interest in this topic stems from the application of tunable fibre lasers to wavelength division multiplexing (WDM) systems, laboratory testing and accurate sensors. In particular this thesis considered the adaptation of the fibre laser to strain sensing. The experimental part of this thesis consisted of the construction of my own tunable fibre laser using a silica fibre Bragg grating (FBG). It also presented, for the first time, the strain characterisation of a microstructured fibre Bragg grating. Finally this thesis examined what must be done to apply this new technology to a broadband tunable fibre laser.

1. Introduction
A fibre laser differs from a traditional laser in that the amplification of light takes place in a length of optical fibre. Sometimes included in the category of fibre lasers are lasers that use a section of optical fibre as the laser cavity, although the amplification of light is achieved through other means such as semiconductor optical amplifiers.

2. Developing my own tunable fibre laser
The figure above depicts the experimental setup for my tunable fibre laser. The laser diode supplies light at a wavelength of 980nm to the ring. This excites the ions in the Erbium doped fibre (EDF) which settle to a lower energy level before returning to their ground state and spontaneously emitting light in the wavelength range of approximately 1520-1570nm. The only wavelength band allowed to circle the ring and be amplified to produce the lasing output is determined by the FBG which reflects only a narrow band (of the order of 0.1nm). The wavelength the FBG reflects, called the Bragg wavelength, is dependent upon the strain, stress and temperature that the grating is exposed to. The graph below shows the laser output at the optical spectrum analyser (OSA) for constant addition of weight, and hence strain, for the FBG.

3. Enhancing the tuning range of the laser
Microstructured polymer fibre is a relatively new technology being pioneered by the Optical Fibre Technology Centre (OFTC). It is only in the last few months that FBGs have been able to be written in mPOF at Aston University using fibre from the OFTC. The next step once a basic tunable fibre laser had been demonstrated was to enhance the tuning range by replacing the silica FBG with an mPOF FBG. This gives a larger tuning range due to the smaller Young’s modulus and larger elastic limit of the mPOF grating which allows the grating to withstand greater strain.

Before connecting an mPOF FBG to the fibre laser a standard and an annealed (dehydrated in an oven at 70°C for 10 minutes) mPOF FBG were strain tested using the setup above right. This experiment demonstrated that annealing the FBG shortened the Bragg wavelength and that the FBGs were both tunable over a range of at least 40nm and perhaps beyond with the equipment limiting the test range. These experiments also showed that this process was reversible at higher strains but that at low strains (0 - 0.25%) the grating did not contract immediately and took considerable time to relax.

4. Attaching the mPOF grating to the laser
Below left is the output of the fibre laser setup with the standard mPOF FBG attached. Below right is the output of the fibre laser setup with the annealed mPOF FBG attached. As can be seen the fibre laser setup is outputting a very low power signal well below lasing threshold, but with a peak at the Bragg wavelength.

5. Conclusion
This thesis established a functional tunable fibre laser, confirmed that mPOF FBGs can be tuned over a large wavelength range and are suitable for implementing tuning in a broadband laser once losses associated with the new technology are overcome.