

Grating writing through the fibre coating using a 248nm excimer laser

Lu Chao* and Laurence Reekie

*School of Electrical and Electronic Engineering
Nanyang Technological University, Singapore 639798

Abstract

Fibre Bragg gratings have been written through the fibre coating using a 248nm excimer laser for the first time. A standard off-the-shelf coating was used, and 92% reflectivity gratings were obtained with an index change of 2.4×10^{-4} .

In the normal process of fibre grating fabrication, all coatings must be stripped off before the grating can be written and, in order to preserve the mechanical strength of the fibre, it must be re-coated soon after the grating is written. This method is both time consuming and has the potential of reducing the fibre strength due to exposure of the bare fibre to the air. To solve the problem, a number of solutions have been proposed. These include using a specially developed UV-transparent polymer coating [1], writing the grating using near UV light around 330nm instead of at more conventional wavelengths [2], writing on-line as the fibre is being pulled [3] and using a specially developed coating which can be removed thermally then immediately re-coating in an automated production system [4]. The polymer used in [1], although it has a lower absorption than the normal UV-curable polymer coating, still has a strong absorption at 248nm or 257nm. This increases the grating writing time and reduces the mechanical strength of the fibre when higher UV exposure power is used [5]. In [2], a specially developed phase mask is needed in order to operate at the non-standard wavelength. In addition, care is also required to control the average laser power in order to reduce damage to the coating. On-line production of fibre gratings [3] is limited to the manufacture of gratings which can be made with a single laser pulse. The method proposed in [4], although attractive, requires both a special coating and an automatic production system. The thermally strippable coating also has a low heat resistance in many applications. In this letter, we demonstrate for the first time writing of a fibre grating through a normal off-the-shelf fibre coating using a wavelength of 248nm. We show that the scheme is both easy and cost effective.

The coating we used is General Electric RTV615 silicone rubber. This coating is thermally curable

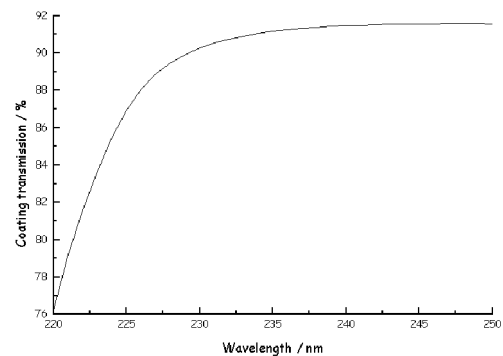


Fig. 1 Transmission characteristics of 150µm film of silicone rubber RTV 615 in the UV region.

and thus does not require a UV absorbing photoinitiator. With a normal specified useful temperature range of -60°C to 204°C , the coating has a better thermal tolerance than standard UV curable polymer coating. This is an important advantage in many applications. To determine the absorption of the material in the UV region, a 150µm thick film of cured silicone rubber was formed between two silica plates. The absorption characteristics of the coating as measured using a spectrophotometer is shown in Figure 1. A silica plate was used as the reference to improve the measurement accuracy. The result clearly indicates a transmission of almost 92% at a wavelength of 248nm. This low UV absorption suggests the possibility of Bragg grating writing through the silicone rubber coating using either a frequency-doubled Ar⁺-ion laser at 244nm or a KrF excimer laser at 248nm. To verify this, we coated a photosensitive boron co-doped silica/germania photosensitive fibre (NA=0.12, $\lambda_{\text{cut-off}}=1050\text{nm}$, diameter=125µm) with the silicone rubber coating. The average coating thickness was 60µm, similar to a normal fibre coating. The grating inscription was carried out using a 248nm excimer laser and a 1540nm phase mask optimised for 248nm operation. A 1cm long grating was produced by

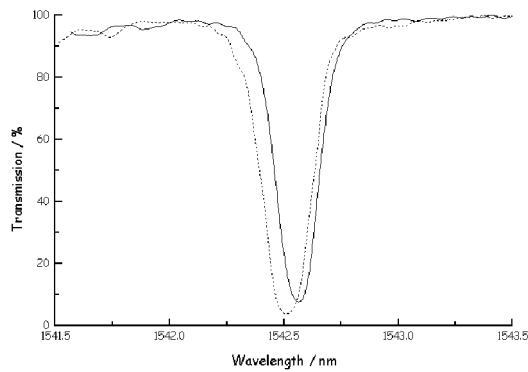


Fig.2 Transmission spectrum of Bragg grating written in coated fibre.

scanning a 3mm wide beam over a section of the coated fibre, each individual part of the fibre receiving an exposure of 3 minutes at 20Hz. The spectrum was monitored using an optical spectrum analyser and 1.55µm LED. The individual pulse fluence was set at 64mJ/cm². A grating with a reflectivity of 92% was obtained, limited by the resolution of the optical spectrum analyser (approximately 0.1nm), corresponding to an index change of 2.4×10^{-4} , and the resulting grating is shown in figure 2. For comparison, we also stripped off the coating and exposed the fibre under identical conditions, and this grating is shown in figure 3. The almost identical result suggests that the effect of writing through the coating is almost negligible. The background ripple outside the grating bandwidth is mainly due to variations in the LED spectrum.

To verify the heat resistance of the coating we have placed a fibre with the silicone rubber coating together with a fibre coated with UV curable polymer on a hot plate with a temperature of

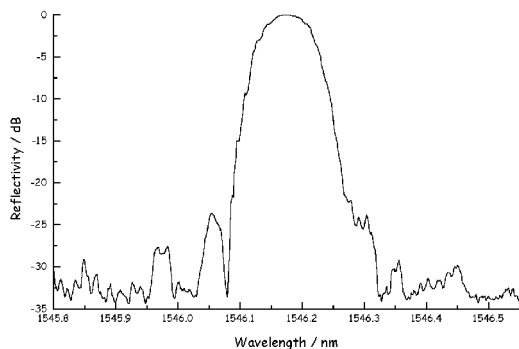


Fig. 3 Transmission spectrum of Bragg grating written in un-coated fibre.

300°C for 3 minutes. A visible darkening of the polymer was observed. However, the effect on the silicone rubber coated fibre was negligible.

In summary, we have demonstrated for the first time the ability to write a fibre grating through standard fibre coating at a wavelength of 248nm. The ability to write through the fibre coating is most useful since it will significantly simplify the grating writing process, particularly for long arrays of gratings as required for fibre sensors. At the same time the longer possible writing time will allow more complicated grating structures to be written. This is important for WDM devices and some sensor applications. The better heat resistance not only means that it can be used in many different applications but also allows the grating to be annealed if there is such a requirement, e.g. after hydrogen loading.

References

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