Wearable LED-based device for phototherapy applications

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Phototherapy with UVA/B or visible wavelengths is used to treat skin disorders such as psoriasis, eczema and vitiligo. Traditionally, phototherapy is carried out in a clinical environment and utilises large fluorescent lamps. These are now being replaced with more efficient light-emitting diodes (LEDs), a trend that is set to continue thanks to the progress of UV LED technology. LEDs are also facilitating the emergence of at-home devices to improve patient convenience and decrease demand on the healthcare system [1]. Current at-home devices consist of inflexible LED arrays, which limits their conformability and produces non-uniform light distribution over the treatment area, in turn limiting their efficacy and wearability [2].

As a solution to this problem, we are engineering a flexible light therapy device that combines LEDs and a sub-mm-thick polydimethylsiloxane (PDMS) light sheet in an edge-lit configuration. PDMS has previously been shown as an effective flexible light guide [3]; its high transparency from 290 nm upwards and its biocompatibility make it an ideal substrate for a wearable phototherapy device. We will describe the effect of coupling LEDs to our PDMS sheet and discuss design strategies for efficient and uniform light extraction to the treatment area. The PDMS acts as a waveguide and the light diffused through the top surface of the sheet is measured as irradiance ($\mu W/cm^2$). By adding scattering particles for light extraction a 10-fold enhancement in irradiance has been demonstrated. Utilising a UV LED (385 nm) at an optical power of 25 mW, this approach produces a uniform emission of 140 $\mu W/cm^2$ over a treatment area of 225 mm^2 (*fig. 1*). Simulations have shown that the addition of diffractive patterns to the sheet also produces an increased uniform emission.

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[2] C. Cochrane et al, Mater Sci Eng C Mater Biol Appl, 2013, **33**, 1170-1175.
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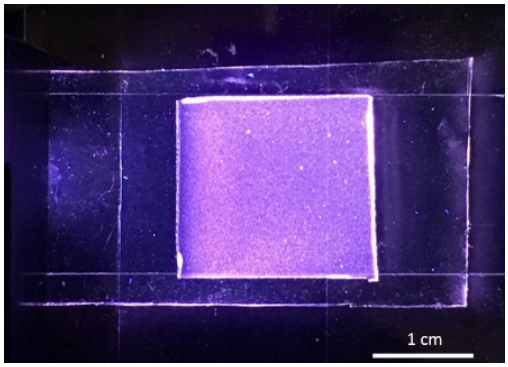

Fig. 1. Light sheet with embedded scattering particles coupled to a UV LED (385 nm) in an edge-lit configuration.