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Wearable LED-based device for phototherapy applications

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Introduction

Phototherapy with UV 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 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 rigid 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.

Methods

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. The PDMS sheet acts as a waveguide and the light diffused through the top surface is measured as irradiance (µW/cm^2) with a spectrally calibrated imaging/detection system. The change in irradiance by embedding scattering titanium dioxide nanospheres has been demonstrated utilising a blue LED (450 nm) with an optical power of 30 mW.

Results & Discussion

This approach produces a uniform emission of 130 µW/cm^2 (± 4%) over a treatment area of 2.25 cm^2, an increase from 3 µW/cm^2 without the nanospheres. Optical modelling shows that when coupling a commercially available “macro-LED” to the PDMS light sheet only 33% of the LED light is coupled. When modelling a custom-shape micro-size LED array, 90% of the LED output is coupled; this should produce a higher irradiance over the treatment area whilst ensuring the small footprint, and mechanical flexibility, of the device.

Conclusion

Uniform irradiance of 130 µW/cm^2 over a 2.25 cm^2 area was achieved by adding scattering particles to an edge-lit PDMS light sheet. Utilising a custom-shape LED array we are planning to develop a flexible light therapy device with an irradiance value of at least 1 mW/cm^2.

References

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