Master thesis : Hardware and Software Development of a Custom Collimated Multi-Wavelength UV Light Source for MSLA 3D Printing

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Hardware and Software Development of a Custom Collimated Multi-Wavelength UV Light Source for MSLA 3D Printing

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Abstract

Masked stereolithography apparatus (MSLA) 3D printing relies on the selective transmission of ultraviolet light through an LCD screen to cure photosensitive resins layer by layer. In this process, the illumination system has a direct influence on the achievable irradiance, exposure uniformity, optical bleeding, and resin compatibility. This work focuses on the development of a custom collimated multi-wavelength UV source for an experimental MSLA printer developed within the Microsys laboratory.

The proposed source operates at 365 nm, 385 nm, and 405 nm, with the objective of extending the range of usable photopolymer resins and investigating the influence of wavelength on pixel-scale optical spreading. The work includes the characterization of existing illumination systems, the study of LED–lens alignment effects, the selection of UV LEDs and collimation optics, and the comparison of two source architectures. Dedicated electronic boards were designed and tested to drive the high-power LEDs, select the active wavelength, and integrate the source into the printer electronics.

The developed hardware was validated electrically and thermally, and a partial optical prototype was characterized experimentally. The measurements showed that the source can produce a collimated illumination with an estimated half-beam angle of approximately 3.5°. With a six-lens prototype, the maximum irradiance measured after the LCD reached 1.58 mW/cm^2 at 365 nm, 4.26 mW/cm^2 at 385 nm, and 5.23 mW/cm^2 at 405 nm. The 405 nm value is comparable to the irradiance of the previous single-wavelength source used in the printer. Simulations of the complete source indicate that the dense *Parmigiana LED1* architecture should provide the best compromise between irradiance and uniformity.

The experiments also highlighted several limitations of the present setup. In particular, the current RGB LCD screen exhibits low UV transmittance, especially at shorter wavelengths, and the irradiance pattern transmitted through a red sub-pixel was found to be much wider than the physical aperture. Although a reduction of this spreading was expected at shorter wavelengths, it was not observed under the tested conditions.

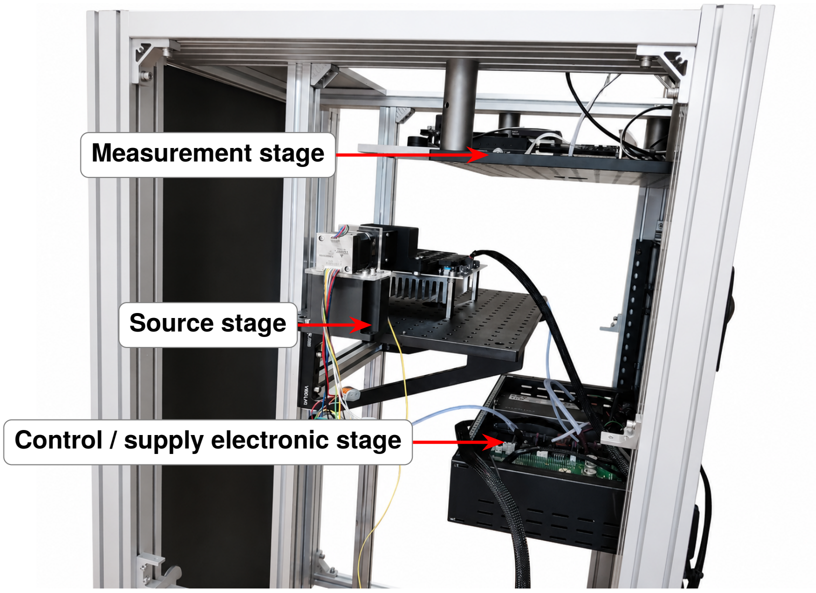

Figure 1: *Final experimental setup used to characterize and validate the multi-wavelength UV sources.*

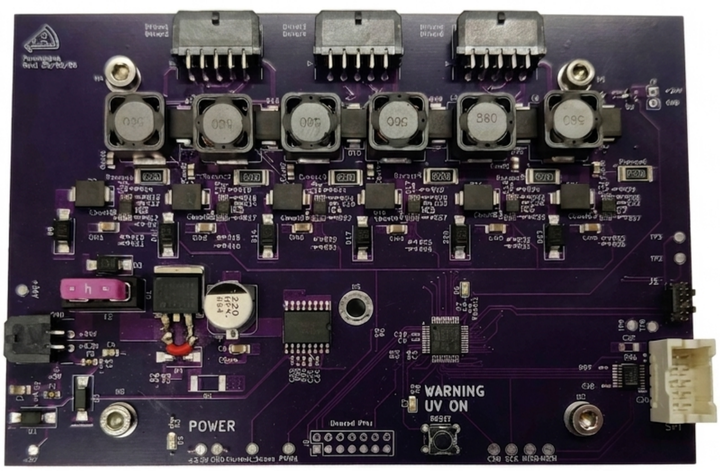

Figure 2: *Custom control board developed to drive the UV LED sources and select the active wavelength.*