

Development of 3D-Printed Parts for Photonic Applications

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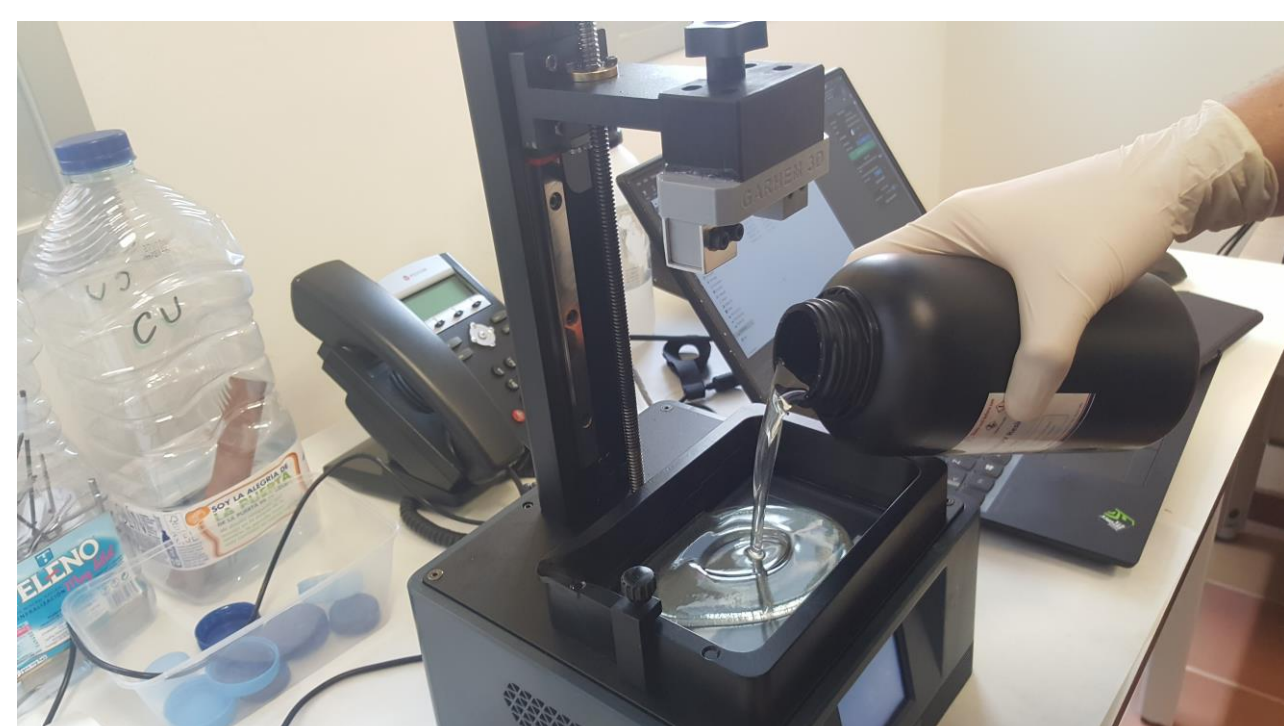
INTRODUCTION & AIM

The development of advanced functional materials through additive manufacturing has opened new opportunities in photonic applications [1,2]. In this work, we report the fabrication of 3D-printed parts using a photo-curable resin doped with rare-earth ions, enabling the production of optically active structures with tailored luminescent properties. By incorporating rare-earth elements into the resin formulation, the resulting manufactured components exhibit characteristic optical emissions when illuminated under appropriate excitation conditions.

The primary objective of this research is the development of 3D-printed parts for information encoding and visual communication. Specifically, structures such as QR codes and ASCII-based patterns are fabricated, in which the encoded information is revealed through luminescent responses arising from the optically active ions. This approach enables secure and contactless information retrieval, with potential applications in anti-counterfeiting, data storage and smart labeling. In addition, the versatility of the printing process allows the fabrication of customized photonic elements for signaling and safety applications.

METHOD

A photo-curable resin doped with rare-earth ions was prepared and homogenized prior to fabrication. The designed structures, including QR codes and ASCII patterns, were processed using a slicer to define optimal printing parameters. Additive manufacturing was carried out using stereolithography-based 3D printers to obtain the final parts.



Figures 1 and 2. 3D printers: Anycubic Ultra (up) and Photon S (right) printers were used for the manufacturing of the parts.

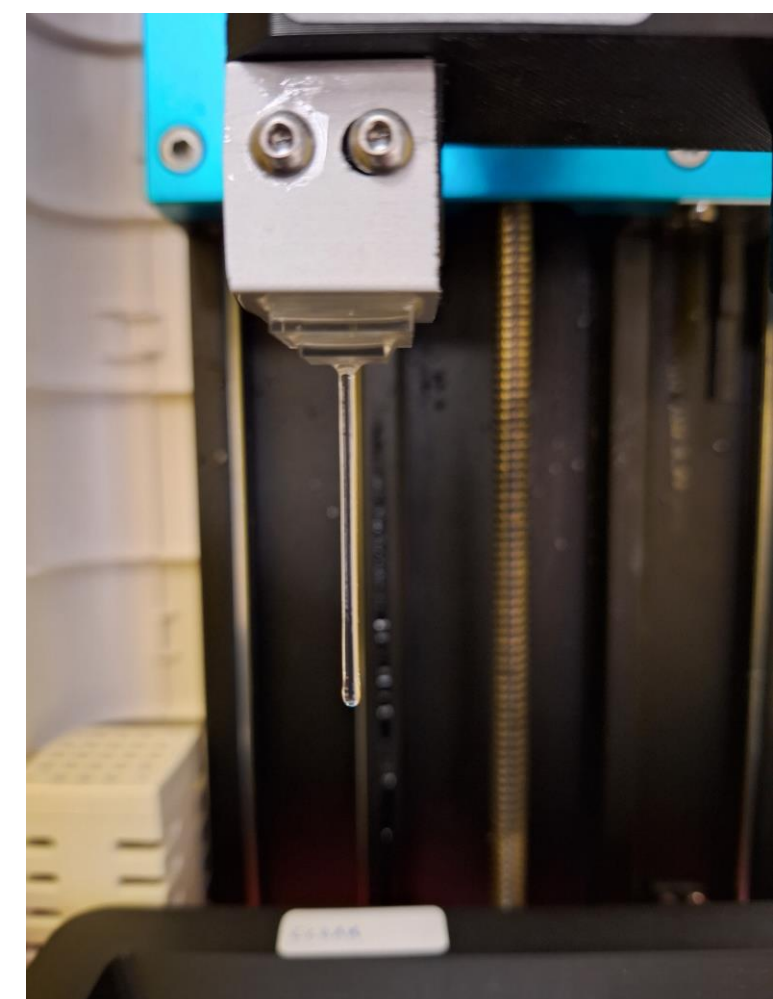
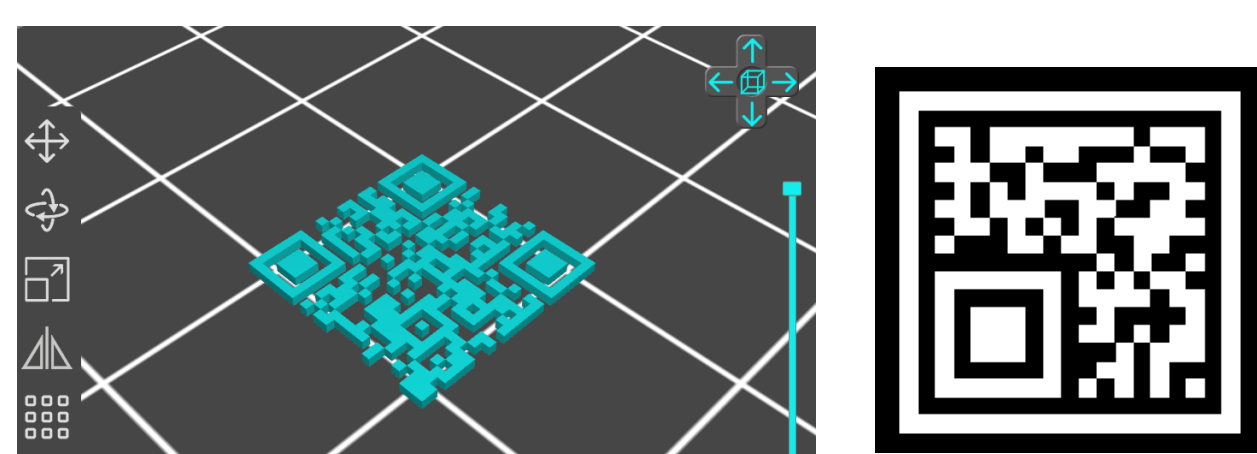


Figure 3. Once the prototypes have been designed, a slicer is used to select the printing parameters.

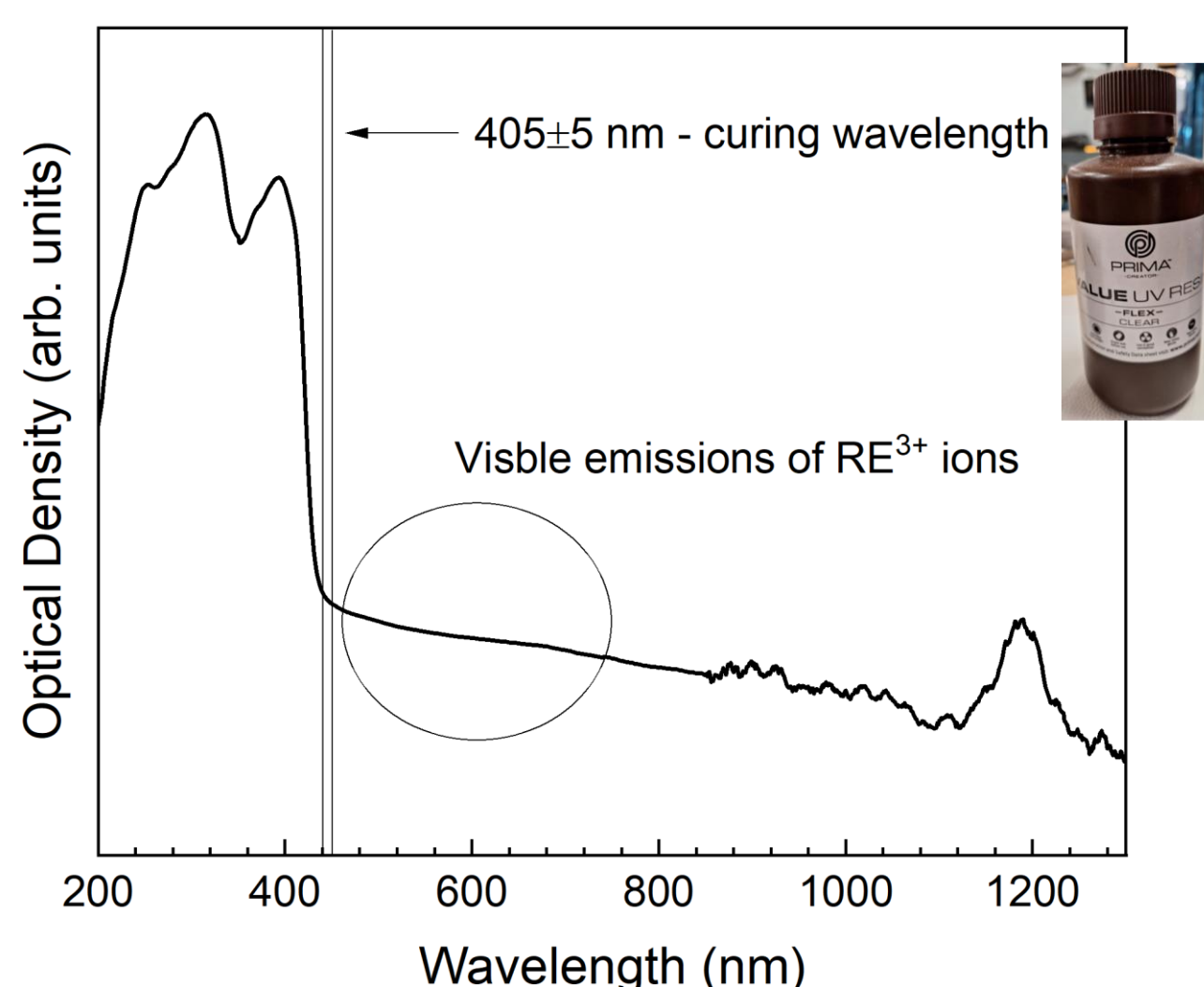
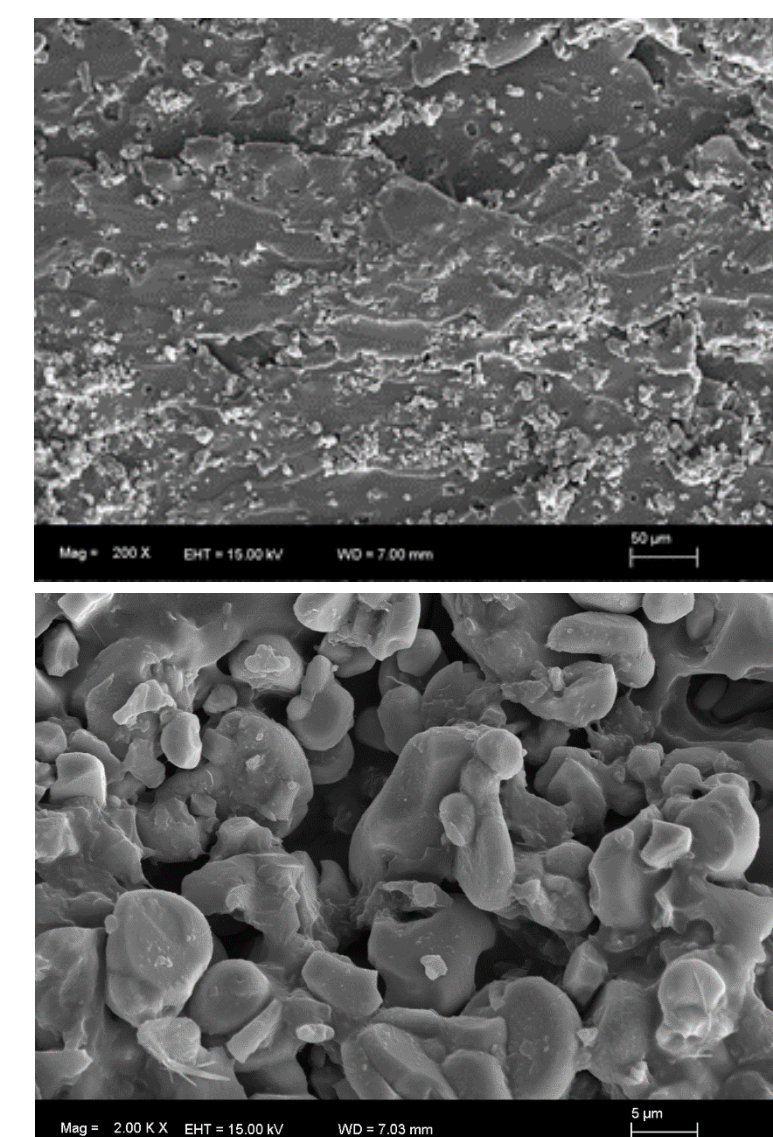
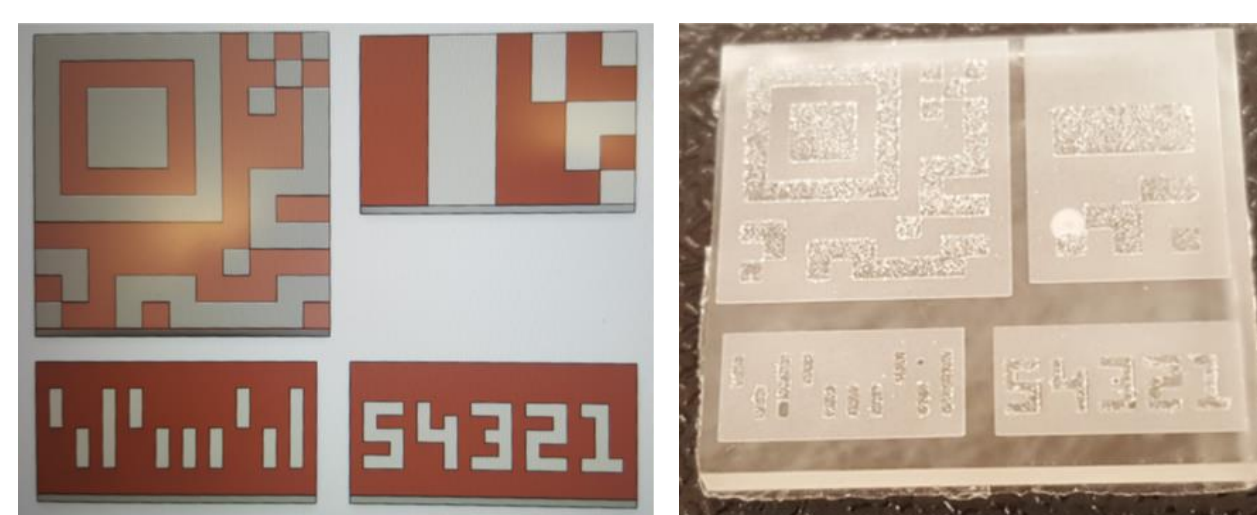


Figure 4. Absorption spectrum of the resin used, showing the curing wavelength and the emission region of the lanthanide ions.



Figures 5 and 6. SEM images of the resin-luminescent particles mixture (top) and of the luminescent particles (bottom).

RESULTS & DISCUSSION



Figures 7 and 8. QR, ASCII, and numbering designs (left), together with the results obtained after 3D printing of the parts (right) explained in the method section.

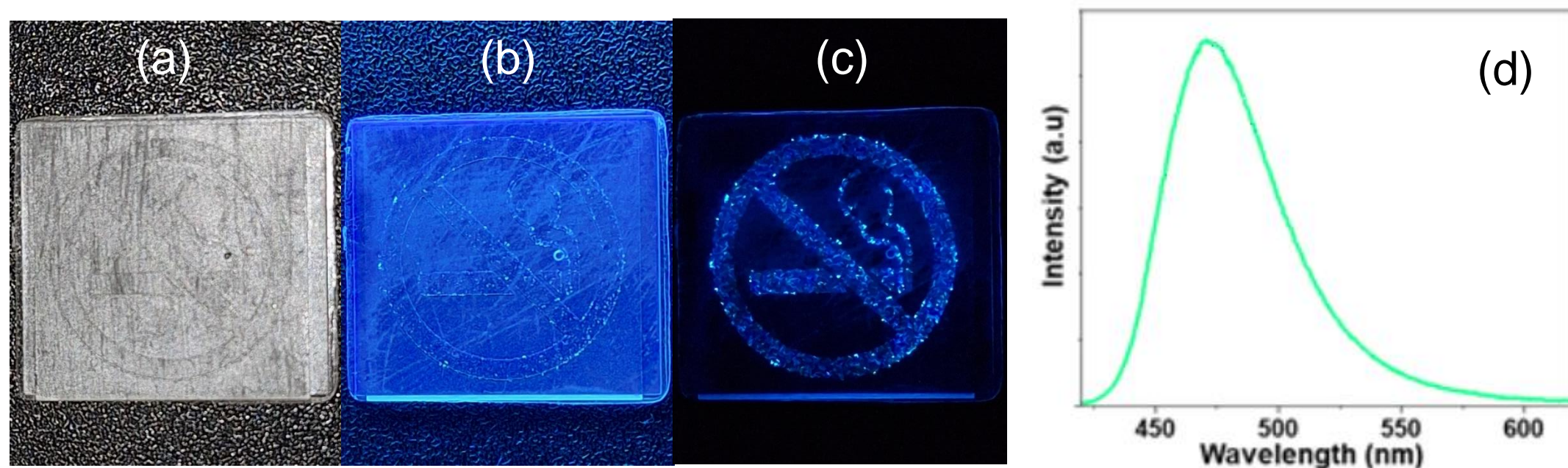


Figure 9. Images of a signaling part doped with Tm^{3+} ions. The sequence shows the part unilluminated (a), the part illuminated with UV light (b) and the part emitting blue light (c). The graph (d) corresponds to the emission spectrum.

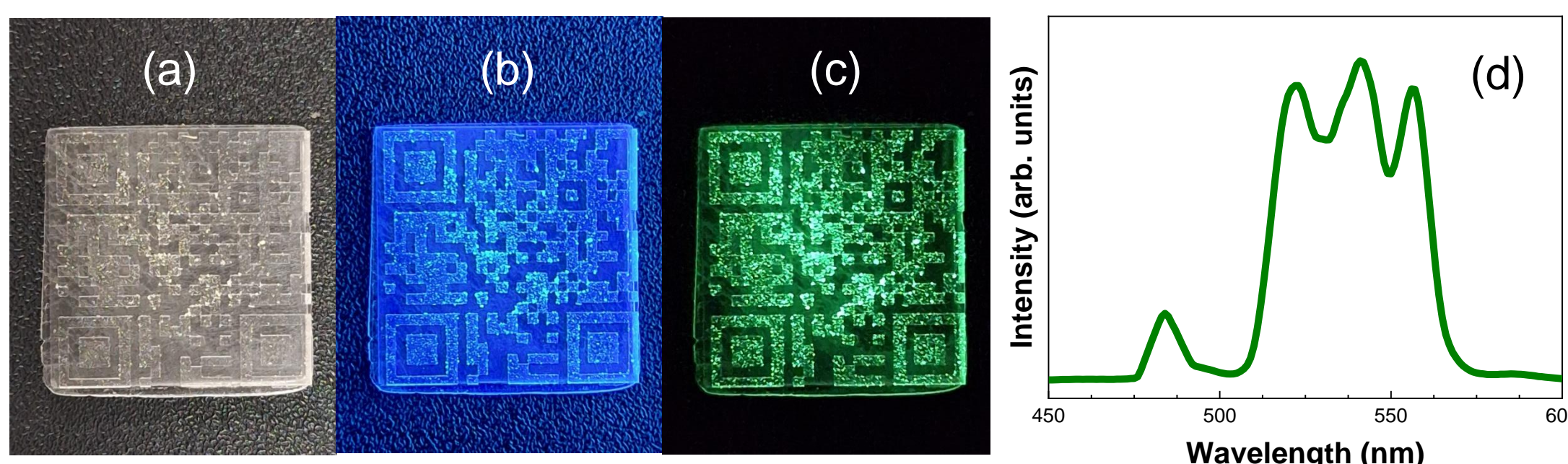


Figure 10. Images of a QR doped with Er^{3+} ions. The photographs show the part unilluminated (a), the part illuminated with an UV lamp (b) and the part emitting green light (c). The graph (d) corresponds to the emission spectrum.

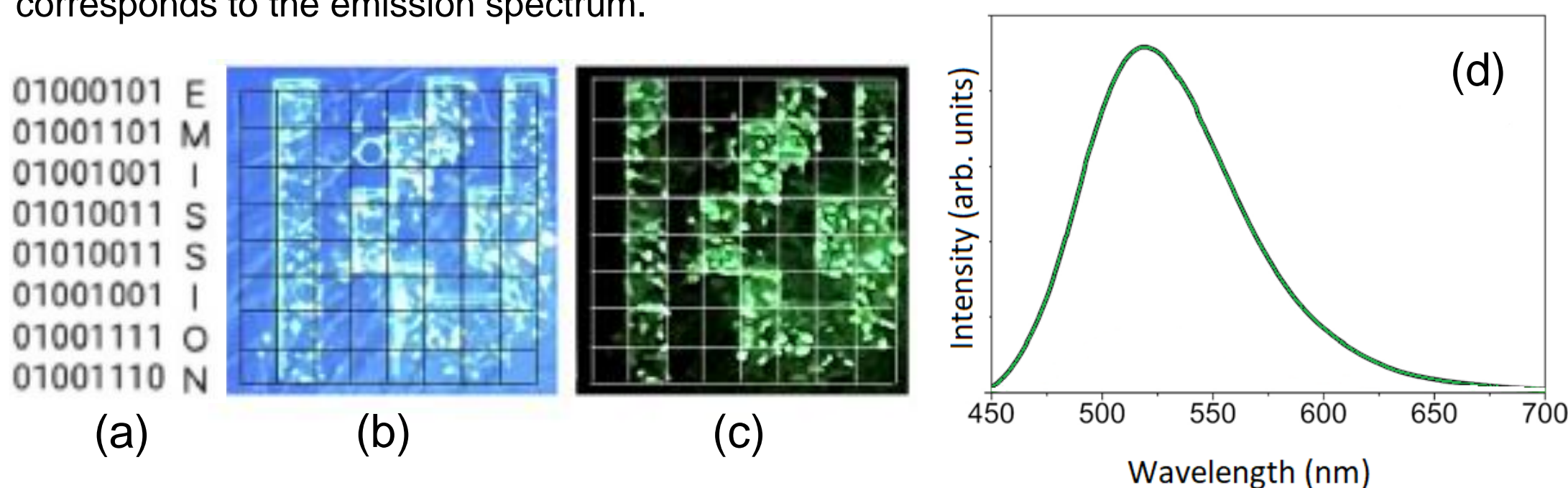


Figure 11. ASCII 3D-pattern doped with Eu^{3+} ions. The code can be decoded as "EMISSION" by exciting and reading in Persistent luminescence mode (a-c). The graph (d) corresponds to the emission spectrum.

CONCLUSION

Incorporating rare-earth ions into photo-curable resins enables the creation of 3D-printed structures with tailored luminescent properties. These printed parts allow secure information encoding, enhancing data protection. This approach offers potential applications in anti-counterfeiting, data storage and smart labeling.

FUTURE WORK / REFERENCES

- Rivera-López, F.; Hernández-Álvarez, C.; Domínguez-Crosa, M.C.; Martín, I.R.; González-Rodríguez, M.; Nuñez, P.; Ríos, S. 3D-Printed $Gd_3NbO_7: Yb^{3+}, Tm^{3+}$ Remote Temperature Sensor with High Sensitivity for Industrial and Biological Applications. *Mater. Today Adv.* 2025, 28, 100642.
- Hernández-Álvarez, C.; Martín-Hernández, P.I.; Martín, I.R.; Rivera-López, F.; Hemmerich, H.; Grzegorzczak, M.; Mahlik, S.; Runowski, M. Optical Temperature Sensor Evaluation in a Working Gear Motor: Application of Luminescence Thermometry in Industrial Technology. *Adv. Opt. Mater.* 2024, 12 (17), 2303328.