

Explanatory accompanying text for Poster:

Interfacial Morphology of TPU Filament on Plasma-Treated Textiles: A 3D Surface Analysis Approach

Diffuse Coplanar Surface Barrier Discharge (DCSBD) plasma represents an environmentally friendly physical method for surface activation of polymeric and textile materials without the use of conventional chemical treatments. In the presented research, DCSBD plasma was applied to investigate the interaction between thermoplastic polyurethane (TPU) filaments and selected textile substrates with different structural morphologies. The study focused on understanding the spatial distribution, localization, and penetration behavior of TPU structures deposited onto textile surfaces before and after plasma activation.

The experimental work combined plasma surface treatment, additive deposition using a 3D printing pen, and advanced confocal microscopy analysis. Textile materials included satin fabrics, polyester lining materials, cotton fabrics, and PES/LY tulle structures characterized by different porosity and surface topology. Several commercially available TPU filaments with different visual and processing characteristics were evaluated, including F3DFilament, 3DPower, and Nocturno filaments. Plasma activation was performed using a DCSBD plasma reactor operating under atmospheric pressure conditions. The treatment was applied directly to textile surfaces and, in selected experiments, also to ready-made dress structures positioned on a mannequin using a specially adapted DCSBD electrode system.

The deposited TPU structures were subsequently analyzed using confocal microscopy. Height-resolved topographical maps and profile analyses were used to evaluate the localization of the deposited filament relative to the reference surface of the textile substrate. Particular attention was focused on the quantified area of TPU localized above and below the textile surface. This approach enabled a semi-quantitative evaluation of the degree of filament penetration into the textile structure and provided information about the interaction mechanism between the molten TPU and the activated textile interface.

The obtained results demonstrated that DCSBD plasma significantly influences the interaction between TPU filaments and textile materials; however, the effect strongly depended on the morphology of the textile substrate and the type of TPU filament. In several systems, plasma activation promoted the formation of a more homogeneous and compact TPU layer localized predominantly above the textile surface, while simultaneously reducing local penetration into the textile structure. Such behavior was particularly visible for selected satin and

polyester lining materials, where plasma activation reduced the relative amount of material localized below the reference surface.

In contrast, textile substrates with a more open structure, such as tulle, exhibited a different interaction mechanism. In these systems, plasma activation could locally increase the penetration of molten TPU between textile fibers, indicating a combined effect of increased surface energy and structural porosity. The results therefore suggest that plasma activation does not represent a universally identical adhesion-enhancing mechanism, but rather modifies the overall spatial behavior of molten TPU on the textile surface.

Confocal microscopy proved to be a highly suitable analytical method for evaluating the topographical behavior of TPU/textile interfaces. The generated height maps and profile analyses enabled direct visualization of localized penetration, surface spreading, and formation of compact surface layers. The combination of confocal imaging and quantitative area analysis provided an advanced interpretation of the interaction between additive polymer structures and plasma-modified textile substrates.

The presented research demonstrates the potential of combining DCSBD plasma technology, textile engineering, additive deposition, and digital topographical analysis for the development of advanced functional and design-oriented textile systems. The results also indicate significant potential for future applications in smart textiles, wearable structures, plasma-assisted additive manufacturing, and interactive educational visualization of material interactions.