Study of the effect of bio-inspired surface texture on the shear strength of bonded 3D-printed materials: Comparison between stainless steel and polycarbonate joints	
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Abstract:
Additive Manufacturing (AM) is one of the important technological pillars of Industry 4.0. Thanks to its tool-free manufacturing and extreme flexibility, AM has the potential to respond to individual customer preferences with a customized final product. Nevertheless, the size of 3D printed products is limited by the size of the build chamber of commercially available printers. In addition, deformations, stability, tolerances, and especially cost are highly dependent on the maximum size of the parts. Therefore, a larger final product can only be realized as an assembly group. Therefore, adhesive bonding appears to be an attractive solution for assembling parts made by AM. In this paper, a comparison of the influence of surface texture on the shear strength of 3D-printed metallic and polymeric adhesive joints was performed. A fish scale (FS) bio-inspired surface texture was chosen to examine how surface patterning influences the strength of joints. Fused deposition modeling (FDM) and selective laser melting (SLM) techniques were used to produce polycarbonate (PC) and stainless steel (17-4 PH) specimens, respectively. The effect of bio-surface and material type on the shear strength of adhesive joints was assessed using the ASTM D4501 standardized block shear testing method. The morphological analysis revealed that FDM exhibits reduced resolution and accuracy, making it less suitable for the additive manufacturing of complex surface features in 3D-printed parts when compared to SLM technology. In addition, bio-surface texturing significantly improved the wettability of stainless steel, requiring the synergy of higher surface free energy and increased surface roughness (FS bio-surface) for super-hydrophilicity, while a combination with lower surface free energy (PC material) and the same surface roughness resulted in hydrophobic behavior. On the other hand, the bio-surface texture greatly enhanced the shear strength (+31%) of stainless steel specimens, compared to PC specimens, due to the increase of physical adsorption forces and the enhancement of the mechanical interlocking effect. The analysis of variance (ANOVA) results highlight the predominant influence of material type on surface wettability (84%), while surface texture has a more pronounced impact on the shear strength of bonded joints (71%).