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Explanatory accompanying text for Poster:

Hybrid Chemical-Plasma Approach for Non-Contact Patterning of Glass Surfaces with Controlled Wettability

The presented research focused on the controlled modification of glass surface wettability using a hybrid combination of selective chemical pre-treatment and diffuse coplanar surface barrier discharge (DCSBD) plasma activation. The study experimentally demonstrated that atmospheric-pressure plasma technology can be effectively combined with commercially available chemical systems to generate localized hydrophilic and hydrophobic regions directly on glass substrates without mechanical patterning or conventional coating deposition.

Glass surfaces were selectively modified using alcohol-based cleaning systems, anti-fog agents, hydrophobic coatings, and surfactant-containing formulations. Subsequent plasma activation was performed using a DCSBD plasma reactor operating at atmospheric pressure in ambient air at an input power of 400 W and an exposure time of 15 s. The treatment enabled significant changes in surface wettability and surface free energy due to plasma-induced oxidation processes and removal of organic contamination.

Surface wettability was evaluated by static contact angle measurements using a KRÜSS Drop Shape Analyzer system. The obtained results confirmed substantial differences between chemically modified and plasma-treated regions. Hydrophobic systems exhibited increased contact angle values, while plasma-treated surfaces showed significantly improved wettability and increased surface free energy. The experiments demonstrated that selective plasma exposure combined with localized chemical pre-treatment enabled the preparation of stable wettability contrasts directly on glass surfaces.

Surface cleanliness and local contamination contrast were additionally evaluated using a Recognoil2W fluorescence-based detector. Fluorescence measurements confirmed the cleaning effect of DCSBD plasma and enabled visualization of differences between plasma-activated and chemically protected regions.

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An important contribution of the research was the transformation of experimentally measured contact angle data into image-based numerical models of local surface free energy distribution. Experimentally obtained wettability values were integrated with binary image masks and transformed into two-dimensional and three-dimensional SFE maps capable of simulating droplet spreading and local wettability behavior.

The developed methodology enabled prediction and visualization of visible droplet-based patterns generated exclusively through controlled wettability contrast. The generated plasma-patterned structures demonstrated the possibility of stable droplet visualization directly on vertical glass surfaces without the use of pigments, printing techniques, or structural engraving.

The results confirmed that DCSBD plasma technology represents a promising tool for environmentally oriented functional surface engineering, non-contact patterning, and design-oriented wettability control of glass materials. The combination of plasma treatment, fluorescence evaluation, contact angle analysis, and image-based numerical modeling provides a novel interdisciplinary approach connecting plasma physics, materials engineering, and digital visualization.