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

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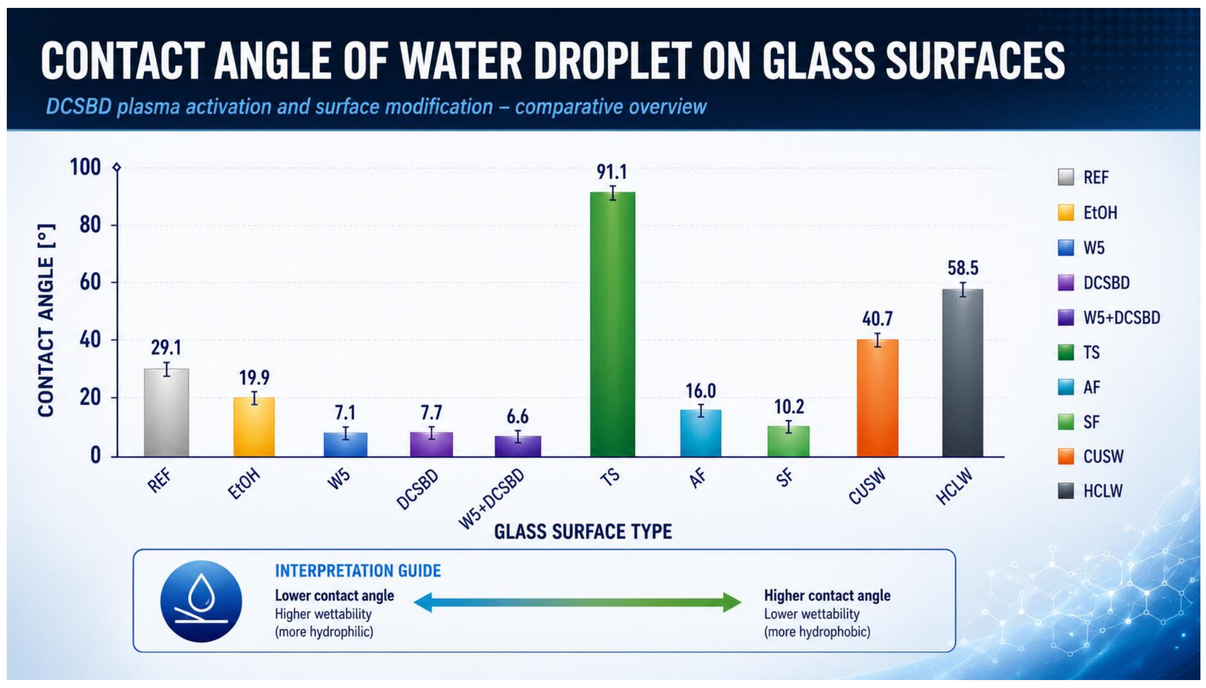
➢ INTRODUCION

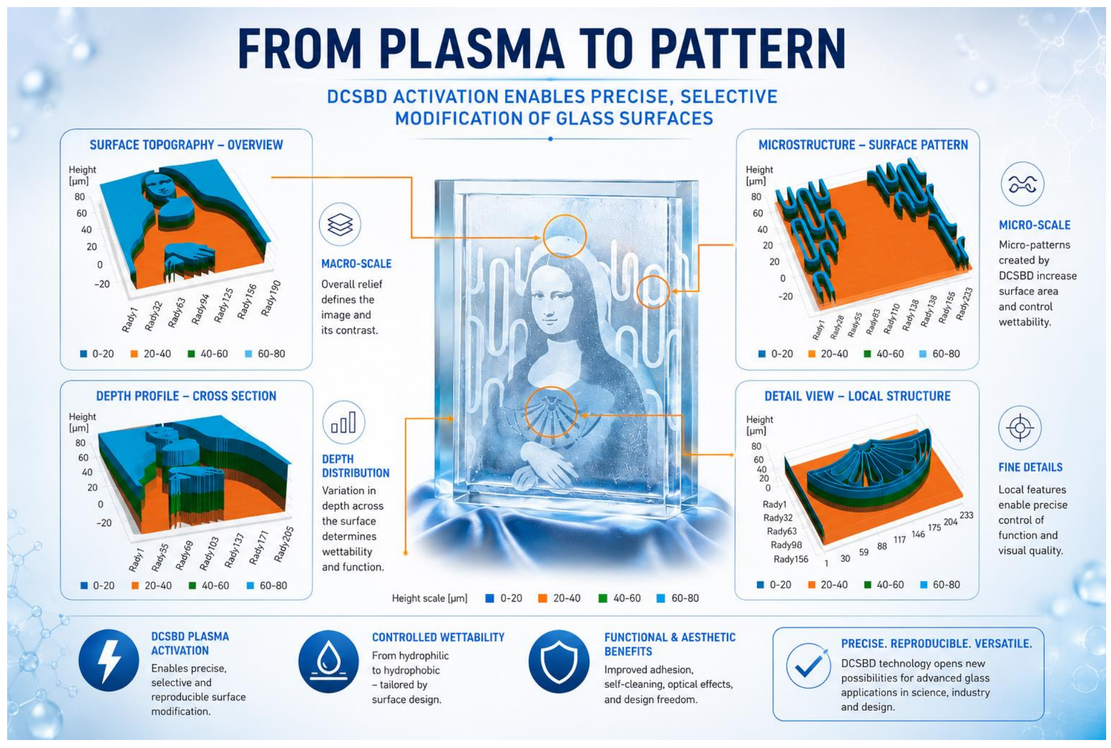
The combination of chemical pre-treatment and DCSBD plasma activation enables controlled, non-contact modification of glass surface wettability and surface free energy (SFE). Spatially selective hydrophilic and hydrophobic regions were experimentally generated, analyzed by contact angle measurements, and transformed into visible plasma-patterned structures through SFE-based modeling and droplet visualization.

➢ METHODS

To visualize the effect of wettability contrast, experimentally measured contact angle values were transformed into **spatial surface free energy (SFE) maps** using image-based **numerical modeling**. Binary image masks combined with experimentally determined SFE values enabled the simulation of local wettability distribution and the **prediction of visible droplet-based patterns on glass surfaces**.

- Surface activation was performed using a diffuse coplanar surface barrier discharge (DCSBD) plasma reactor at an input power of 400 W and an exposure time of 15 s.
- Contact angle measurements and surface free energy (SFE) evaluation were carried out using a KRÜSS Drop Shape Analyzer system.
- Surface cleanliness and contamination contrast were evaluated using a Recognoil2W fluorescence-based detector.





➢ THE RESULTS

- ✓ DCSBD plasma treatment combined with selective chemical pre-treatment enabled controlled modification of glass surface wettability.
- ✓ Commercially available agents, including an alcohol-based glass cleaner, anti-fog coating, hydrophobic coating, and surfactant-containing systems, were successfully used to create localized contrasts in surface free energy.
- ✓ Surface wettability was evaluated using a SEE System contact angle analyzer through contact angle measurements and subsequent calculation of SFE components.
- ✓ Spatially selective surface activation was achieved by mask-assisted plasma exposure, enabling the formation of defined hydrophilic and hydrophobic regions on glass surfaces.
- ✓ Experimentally obtained SFE data were transformed into two-dimensional and three-dimensional visualization models for prediction and simulation of local wettability contrast.
- ✓ The generated plasma-patterned structures enabled stable vertical presentation of water-droplet-based visual effects directly on glass substrates.
- ✓ The results demonstrate the potential of DCSBD plasma technology for functional surface engineering, non-contact patterning, and design-oriented wettability control of glass materials.

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