# PLASMA APPLICATIONS: Surface Adhesion and Wettability

For references citing the use of our plasma cleaners in adhesion and wettability applications, see the Surface Adhesion and Surface Wettability categories in the References: Technical Articles page.

## Benefits of Plasma Treatment

- Remove residual organic impurities and weakly bound organic contamination
- Prepare surfaces for subsequent processing (e.g. film deposition or adsorption of molecules)
- Improve surface coverage and spreading of coatings and enhance adhesion between two surfaces
- Modify wettability to render a surface hydrophilic [Figure 1 and Figure 2] or hydrophobic [Figure 3] with the appropriate process gas(es)
- Affect only a few monolayers of the surface; does not change bulk properties of the material
- Can treat a wide variety of materials as well as complex surface geometries; examples include:
  - Semiconductor wafers and substrates (Si, Ge)
  - Glass slides and substrates
  - Oxides (quartz, indium tin oxide (ITO), $TiO_2$, $Al_2O_3$); mica
  - Polymers (PE, PDMS, PEEK, PTFE, PLA)
  - Metal surfaces (gold, stainless steel)
  - Electron microscopy (EM) grids

## Applications

- Surface preparation of substrates prior to self-assembly experiments
- Surface preparation of electron microscopy (EM) sample grids
- Plasma cleaning of printed circuit (PC) boards and die surfaces prior to bonding
- Plasma treatment of dental implant and impression mold materials
- Plasma treatment of biomaterials and biomedical devices prior to functionalizing surface
- Plasma treatment of fibers to improve adhesion to matrix in fiber-reinforced composite materials
- Study of adhesion characteristics of dissimilar materials by mechanical testing or atomic force microscopy (AFM) force measurements

## Processing Methods

- Oxygen or air plasma
  - Removes organic contaminants by chemical reaction with highly reactive oxygen radicals and ablation by energetic oxygen ions
  - Promotes surface oxidation and hydroxylation (OH groups); increase surface wettability
  - Oxidation may be undesirable for some materials (e.g. gold) and can affect surface properties
- Argon plasma
  - Cleans by ion bombardment and physical ablation of contaminants off the surface
  - Does not react with the surface or alter surface chemistry
- Carbon tetrafluoride ($CF_4$) plasma
  - Forms hydrophobic coating of fluorine-containing groups (CF, $CF_2$, $CF_3$)
  - Decreases number of hydrophilic polar end groups on surface; decreases surface wettability
- Surfaces should be used immediately after plasma treatment; plasma-treated surfaces may recover their untreated surface characteristics with prolonged exposure to air
- Suggested process parameters values for plasma treatment using a Harrick Plasma cleaner (some experimentation may be required to determine optimal process conditions)
  - Pressure: 100 mTorr to 1 Torr
  - RF power: Medium or High
  - Process time: 1-3 minutes

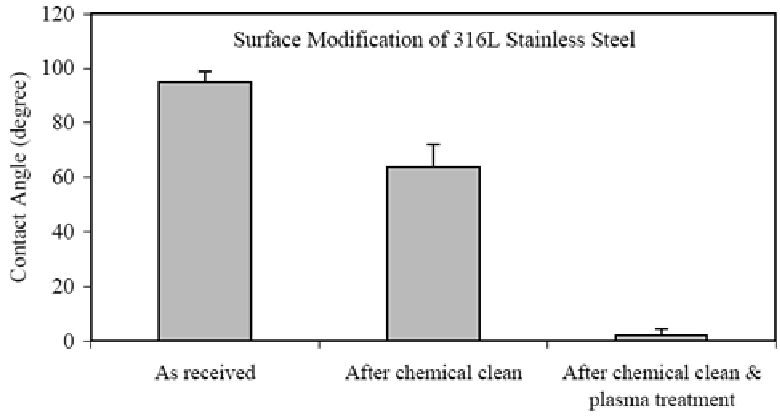


*Figure 1.* Water drop contact angle measurement on 316L stainless steel (a) as received, (b) after chemical clean (ultrasonication in 70% ethanol, acetone, and 40% nitric acid), and (c) after chemical clean and $O_2$ plasma treatment using a Harrick Plasma cleaner. Data from Mahapatro, A., D. M. Johnson, D. N. Patel, M. D. Feldman, A. A. Ayon, C. M. Agrawal. "Surface Modification of Functional Self-Assembled Monolayers on 316L Stainless Steel Via Lipase Catalysis." Langmuir (2006) 22: 901-905.

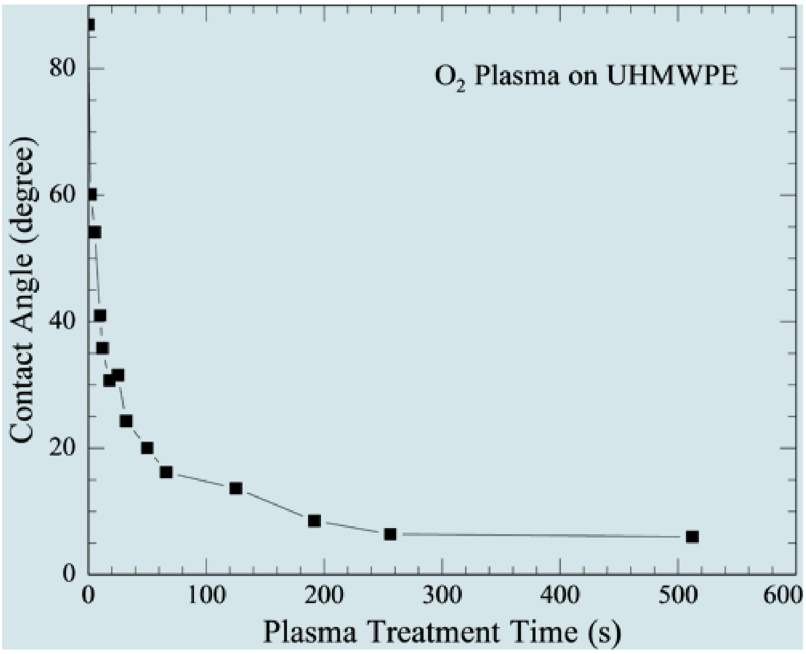


*Figure 2.* Water droplet contact angle measurement on ultrahigh molecular weight polyethylene (UHMWPE) as a function of O2 plasma treatment time using a Harrick Plasma cleaner. Data from Widmer, M. R., M. Heuberger, J. Vörös, N. D. Spencer. "Influence of Polymer Surface Chemistry on Frictional Properties under Protein-Lubrication Conditions: Implications for Hip-Implant Design." Tribol. Lett. (2001) 10: 111-116.

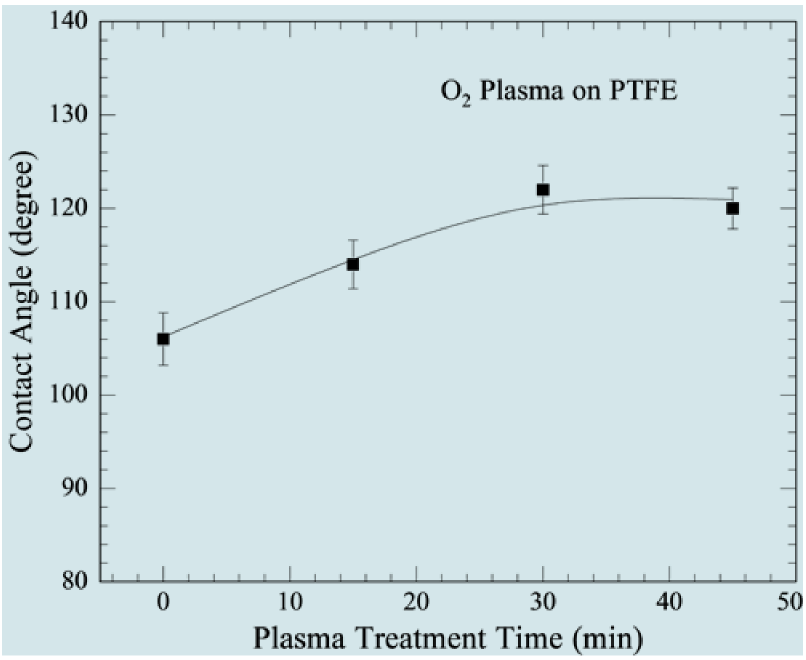


*Figure 3.* Water droplet contact angle as a function of $O_2$ plasma treatment time, using a Harrick Plasma cleaner, on poly(tetrafluoroethylene) (PTFE), indicating increased hydrophobicity. Plasma treatment produces nanoscale roughness that increases hydrophobicity. Data from Lee, S.-J., B.-G. Paik, G.-B. Kim, Y.-G. Jang. "Self-Cleaning Features of Plasma-Treated Surfaces with Self-Assembled Monolayer Coating." Jpn. J. Appl. Phys. (2006) 45: 912-918.