PLASMA APPLICATIONS:
Microfluidic Devices

For references citing the use of our plasma cleaners in microfluidic applications, see the Microfluidic Devices link to category of the References: Technical Articles page.

Benefits of Plasma Treatment for Microfluidic Device Fabrication

- Quickly render poly(dimethylsiloxane) (PDMS), glass, and other polymer surfaces hydrophilic through plasma oxidation [Figure 1]
- Bond oxidized PDMS surfaces and seal irreversibly to create leak-tight channels in microfluidic devices
- Hydrophilic surfaces enhance fluid flow and wetting of channels in microfluidic devices
- Pattern surfaces with alternating hydrophilic-hydrophobic regions

Applications

- Study of chemical reactions and fluid flow on micron scale
- Detection of biological organisms or chemical species
- Clinical diagnostics and drug screening for medical research
- Manipulation of fluid on cellular length scale (microns) for biological research
- Growth of cell and tissue cultures

Processing Methods

- General processing sequence
  - Pattern PDMS by replica molding from a master mold
  - Oxidize PDMS in O_2 or air plasma, etching hydrocarbons and leaving silanol (SiOH) groups on the surface, rendering the surface hydrophilic
  - Place in contact with another oxidized PDMS or glass surface to form bridging Si-O-Si bond at the interface, creating an irreversible seal
- Suggested process protocol guidelines and process parameter values for plasma treatment of PDMS using a Harrick Plasma Cleaner (some experimentation may be required to optimize process)
  - Use oxygen (O_2) or room air as the process gas
  - Pressure: 100 mTorr to 1 Torr
  - RF power: Medium or High
  - Process time: 20-60 seconds
  - An example protocol for PDMS plasma treatment using a Harrick Plasma cleaner as demonstrated in a video published by the Jeon Research Group

    Harris, J., H. Lee, B. Vahidi, C. Tu, D. Cribbs, N. L. Jeon, C. Cotman. "Fabrication of a Microfluidic Device for the Compartmentalization of Neuron Soma and Axons." (08/22/2007), Journal of Visualized Experiments, 7, (http://www.jove.com/index/Details.stp?ID=261).

  - Avoid extended plasma treatment times; prolonged plasma exposure causes cracking in PDMS and migration of low molecular mass molecules from bulk to surface, decreasing the number of hydrophilic SiOH groups and resulting in weak or incomplete bonding

    Bhattacharya, S., A. Datta, J. M. Berg, S. Gangopadhyay. "Studies on surface wettability of poly(dimethyl) siloxane (PDMS) and glass under oxygen-plasma treatment and correlation with bond strength." J. Microelectrom. S. (2005) 14(3): 590-597.

  - Oxidized surfaces should be brought into contact immediately after plasma treatment to achieve strongest bond possible
  - PDMS surface recovers hydrophobic properties (ages) with time after plasma treatment (~1 hour)

    Hillborg, H., J. F. Ankner, U. W. Gedde, G. D. Smith, H. K. Yasuda, K. Wikström. "Crosslinked polydimethylsiloxane exposed to oxygen plasma studied by neutron reflectometry and other surface specific techniques." Polymer (2000) 41: 6851-6863.

    Duffy, D. C., J. C. McDonald, O. J. A. Schueller, G. M. Whitesides. "Rapid Prototyping of Microfluidic Systems in Poly(dimethylsiloxane)." Anal. Chem. (1998) 70: 4974-4984.

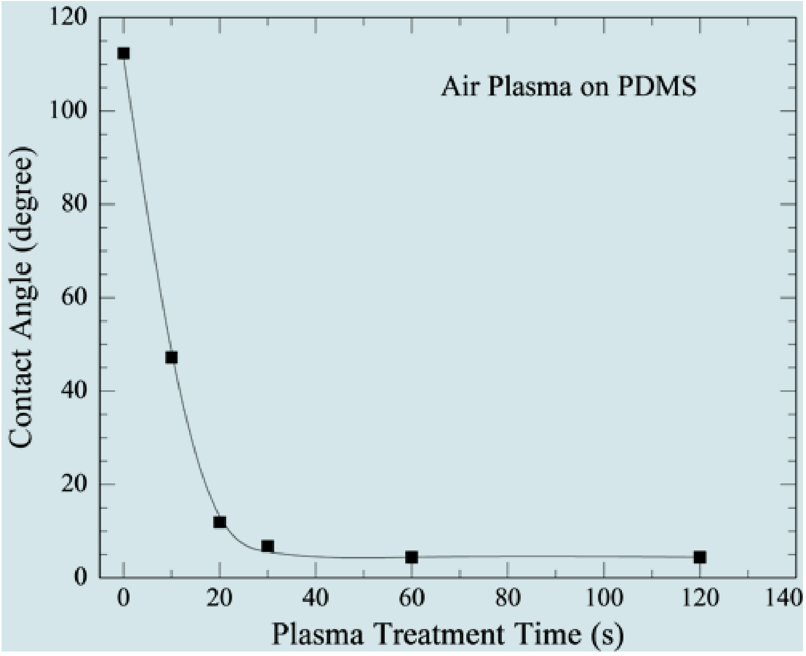

Figure 1. Water drop contact angle on a blank poly(dimethylsiloxane) (PDMS) surface as a function of air plasma treatment time using a Harrick Plasma cleaner. Data from Jiang, X., H. Zheng, S. Gourdin, P. T. Hammond. "Polymer-on-Polymer Stamping: Universal Approaches to Chemically Patterned Surfaces." Langmuir (2002) 18: 2607-2615; Zheng, H., M. F. Rubner, P. T. Hammond. "Particle Assembly on Patterned "Plus/Minus" Polyelectrolyte Surfaces Via Polymer-On-Polymer Stamping." Langmuir (2002) 18: 4505-4510.