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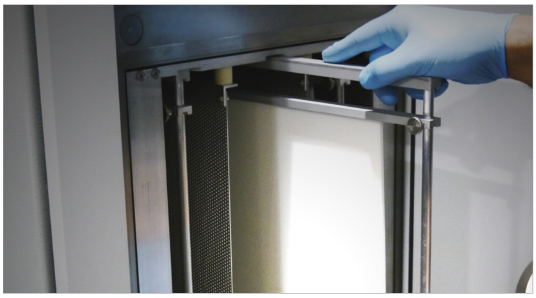
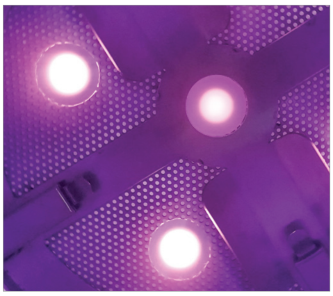
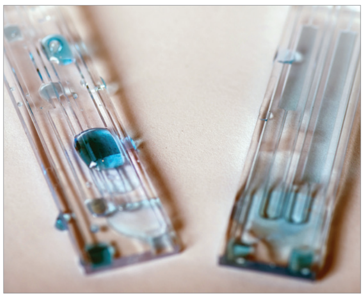
Plasma treated PDMS for improved bonding performance of microfluidic devices

Plasma processing has been an essential production tool for more than 30 years in the fabrication of microelectronic devices for example. Over this period, plasma processes have also permeated a much broader range of industries: automotive, medical, textiles, and plastics to name but a few. This paper discusses the advantages of plasma treatment for improved bonding performance of microfluidic devices.





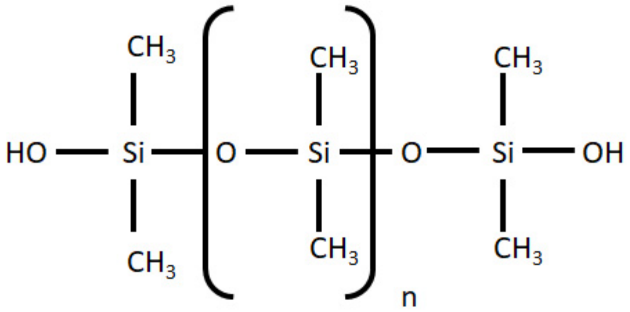


Henniker Plasma | **Address:** 3 Berkeley Court, Manor Park, Runcorn, WA7 1TQ, UK
Tel: +44 (0) 1925 830 771 **Fax:** +44 (0) 1925 800 035
Email: info@plasmatreatment.co.uk **Web:** www.plasmatreatment.co.uk

Plasma Treated PDMS for improved bonding performance of microfluidic devices

What is PDMS?

Polydimethylsiloxane (PDMS) – is a member of a group of polymeric organosilicon compounds that are widely known as silicones. It is the most widely used of these compounds and is featured in applications ranging from medicines and cosmetics to silly putty. In this application we concentrate on the use of PDMS in microfluidic device fabrication.



Molecular structure of PDMS.

Why PDMS?

PDMS has a number of properties which make it favourable for use in creating microfluidic devices;

- Biocompatible
- Low cost
- Few nm resolution moulding
- Low auto florescence
- Transparent (240nm - 1100nm range)

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Limitations

One key limitation of PDMS when used in this application is it's poor adhesion to glass, which lead to premature device failure.

Our Solution

The Henniker HPT-200 system is developed and optimised to produce consistent plasma treatment performance for reliable & repeatable bonding. Both the glass and PDMS substrates were treated with air plasmas, at low pressure, with all settings under microprocessor control.

On both substrates the treatment is effective at removing hydrocarbon groups (CxHy) leaving behind silanol groups on the PDMS and OH groups on this glass substrate respectively. This allows strong Si – O – Si covalent bonds to form between the two materials vis the process as shown in Fig 1&2.

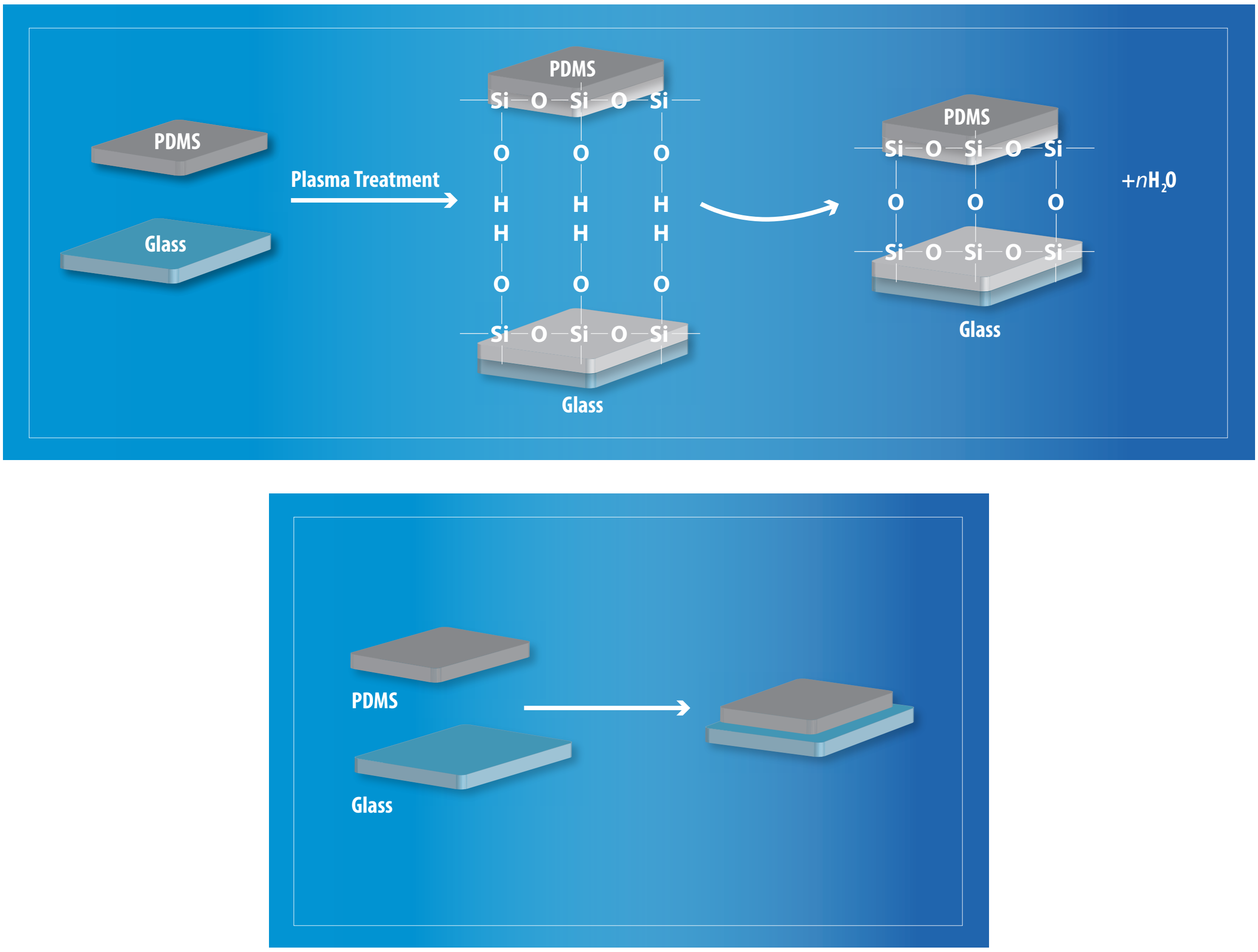

Fig 1& 2. Schematic diagrams of the plasma treatment process to improve surface adhesion

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Results

Contact Angle Measurements

Indicate whether a surface is hydrophobic (over 90°) or hydrophilic (under 90°) by the angle a water drop makes with the surface. Here we can see that increasing the time or power of an air plasma treatment on PDMS leads to the surface becoming more hydrophilic.

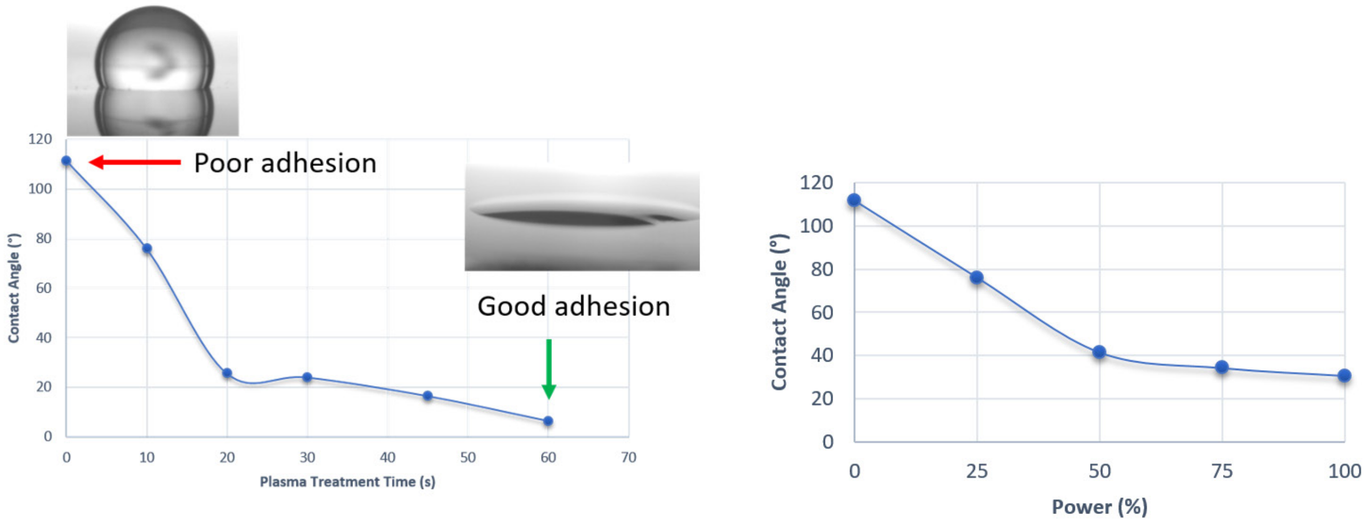

Fig 3. Contact angle variations with increasing treatment time at 25% power (left) and increasing power with 10s exposures (right). Both show a switch between hydrophobic to hydrophilic behaviour. Insets show example droplets.

This switch to more hydrophilic behaviour suggests that the proposed treatment has been a success and that the – OH termination associated with silanol groups is now exposed. This will lead to improved bonding of the PDMS to the glass substrates.

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X-Ray photoelectron spectroscopy (XPS)

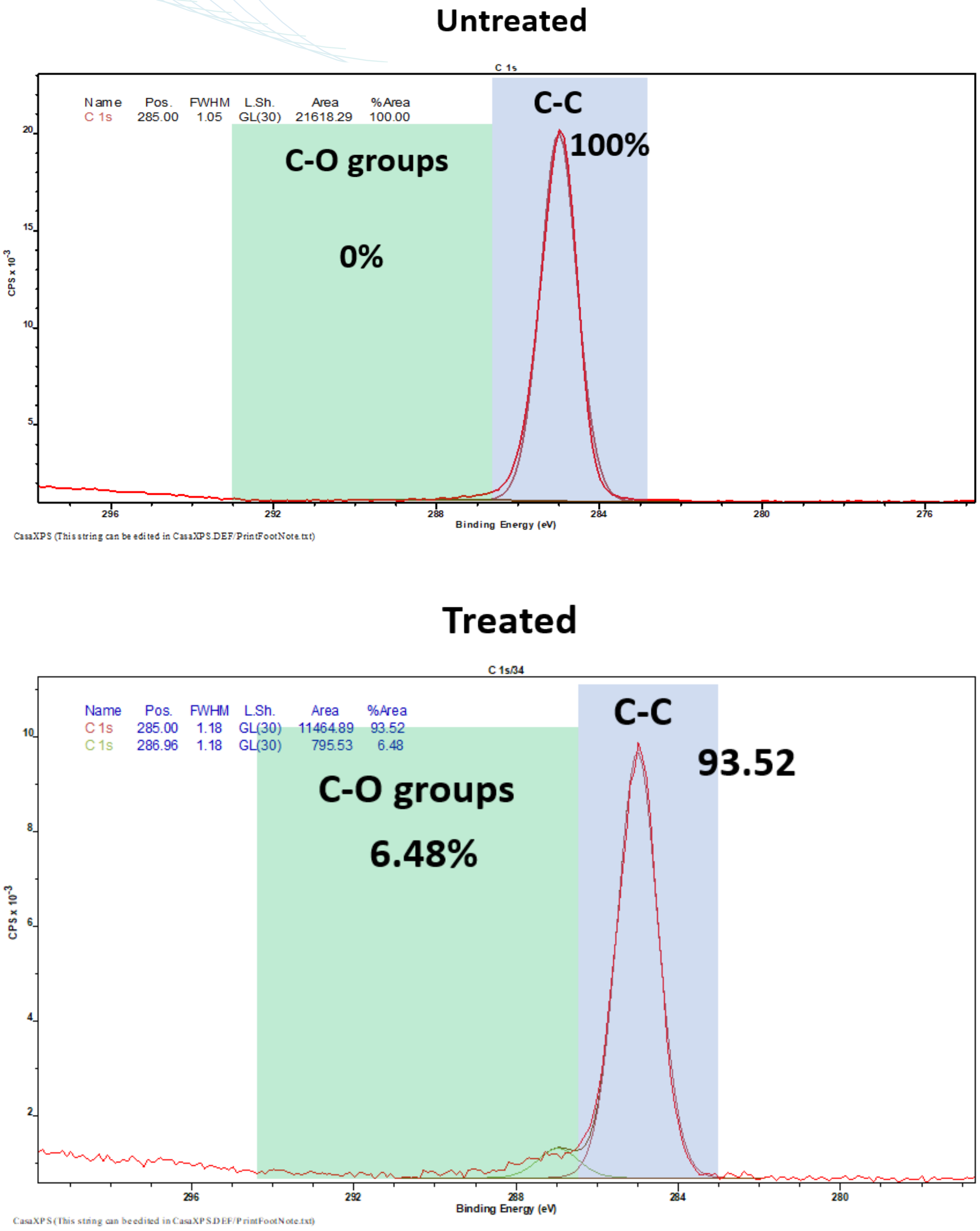

Fig 4. XPS results from untreated (Top) and oxygen treated (Bottom) samples highlighting the presence of C-O groups after treatment.

XPS is a widely used to technique to analyse the functional groups present on the surface of a substrate. Here we use XPS to show how C-O groups are absent prior to plasma treatment (in this case with oxygen plasma) and present after the treatment. Thus indicating a successful surface modification.

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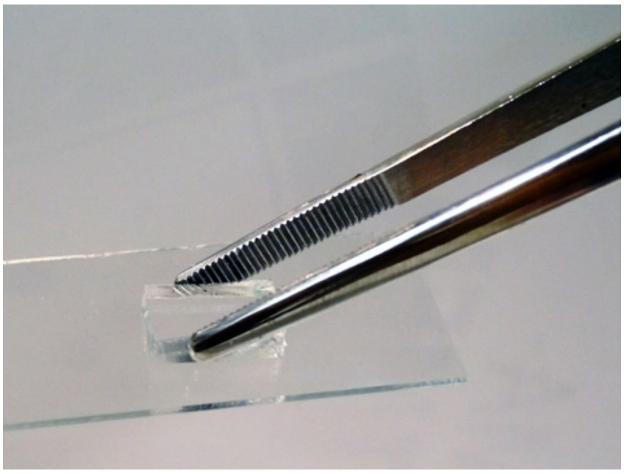
Conclusions

Bonding of PDMS to glass is a key issue in the use of the material in fabricating microfluidic devices.

Using a Henniker model HPT-200 benchtop plasma system to treat PDMS substrates alongside glass substrates, this problem has been addressed. Plasma treatment has been shown to improve the wettability of both surfaces. Leading to increased bonding between the 2 substrates which is highlighted in Fig 5.

The system can also be optimised to bond PDMS to thermoplastic materials.



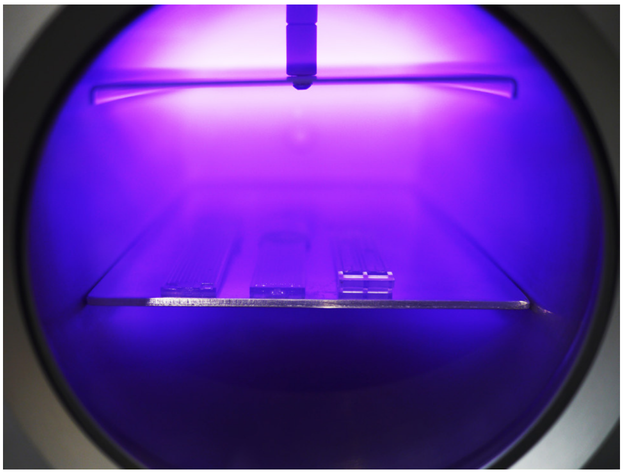


Fig 5. (left) Bonded PDMS and glass following a plasma treatment in a Henniker HPT-200 machine.

Fig 6. (right) PDMS microfluidic channels undergoing plasma treatment.

This is just one example of how Henniker plasma systems can be used to solve a key problem.

Acknowledgements

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Tel: +44 (0) 1925 830 771 **Fax:** +44 (0) 1925 800 035
Email: info@plasmatreatment.co.uk **Web:** www.plasmatreatment.co.uk

PRINCETON SCIENTIFIC CORPORATION
PO Box 148
Easton, PA 18044
Phone: 609 924 3011
Fax: 609 924 3018
Email: info@princetonscientific.com
Web: www.princetonscientific.com

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