

Control of surface energy

The surface energy of the polymer surface is related to the chemistry of the surface. Fluorine atoms lower the surface energy whereas oxygen raises the surface energy of most polymer surfaces. Thus the gas used in any vacuum plasma treatment can be used to not only clean the surface but also change the surface chemistry. Using an oxygen containing plasma has two benefits. The first is that the oxygen will react with any hydrocarbons so that they are converted to volatile species that can be pumped away. The second benefit is to substitute some of the atoms that are sputtered away by the bombarding plasma. This substitution raises the surface energy and also provides a higher bonding strength. The metal to oxygen bond requires a higher energy to break the bond and so the adhesion is greater.

There can be a danger in plasma treating polymer surfaces. If a little plasma treatment is beneficial too much plasma treatment can be damaging. The plasma is required to break bonds and the aim is to break enough bonds to maximise the adhesion but no more. As the bonds are broken and some replaced with oxygen the surface energy rises and this process will continue to a maximum surface energy level. If the plasma treatment continues the surface energy will remain more or less constant for a time and with continued treatment the surface energy will eventually begin to fall. Unfortunately the adhesion does not match this behaviour. The adhesion will initially improve with the increasing surface energy. Once the surface energy plateau is reached the adhesion will then start to fall even though the surface energy remains at the high plateau level. This decline in adhesion is due to the continued bombardment of the surface that further fragments the polymer chains into shorter and shorter chain lengths. These shorter polymer chains are no longer bound into the surface as well as when they were full length and this is the cause of the decline in adhesion. In effect the original low molecular weight contaminant weak boundary layer has been removed but then a new weak boundary layer has been produced by excessive bombardment causing surface fragmentation.