

Plasma Basics

Plasma is often called the "Fourth State of Matter". Although found in virtually every home and business, gas plasma is not well known. In fact, plasma is quite common - it is estimated that 99% of the visible universe consists of plasma. Earthbound plasmas include lightning, fluorescent lighting, arc welders, and computer displays.

Plasma is a state of matter just as a solid, liquid or gas. Add enough energy to a gas and you get the plasma state. Consider a sample of gas in a fixed, closed system. This sample of gas will exert a certain pressure and have a specific temperature due to molecular collisions inside the system. These collisions are mainly elastic collisions that change the molecules speed and direction. If a collision has enough energy, an ion may form by the ejection of an electron. This is an inelastic collision (in any gas there is nearly always some degree of ionization and a small population of free electrons). For the most part, the neutral and small quantities of charged particles drift randomly with a range of speeds nearly ignoring the force of gravity.

Scientists take advantage of the few free electrons by accelerating them with electromagnetic radiation (usually radio frequency at 13.56 MHz). If an electric field is applied to a gas, the few free electrons will accelerate and gain kinetic energy ($KE=0.5mv^2$). As a highly energetic electron collides with a neutral molecule the molecule may ionize by either ejecting an electron or accepting the electron. If an electron is ejected, the newly free electron quickly feels the electric field and gains energy. The process is said to "avalanche" in this way and results in an intense quasi-neutral cloud of electrons, ions, and neutrals in constant agitation, as long as the electric field is present.

By controlling the parameters of RF power, chamber pressure, gas flow, and exposure time, plasma chemistry can induce useful changes to a substrate surface.