



**PLASMA EQUIPMENT TECHNICAL SERVICES  
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#### WHAT IS PLASMA?

Plasma is often described as "the fourth state of matter". The first three states - SOLID, LIQUID, AND GAS - are familiar because they exist all around us. Plasma, though abundant elsewhere in the universe, occurs only under certain circumstances here on earth.

Just as it takes energy to transform a solid into a liquid, or a liquid into a gas, it requires energy to create plasma. The right amount of energy, applied to a gas, will transform the gas into plasma, which is a mixture of electrically charged and neutral particles, including electrons, atoms, ions, and free radicals. Plasma conducts electricity and reacts collectively to electromagnetic forces.

Natural occurrences of plasma include LIGHTENING and the AURORA BOREALIS (also known as the "NORTHERN LIGHTS"). Common man-made examples of plasma in action are NEON SIGNS and FLUORESCENT LIGHTS.

Plasma, as mentioned before, reacts to electromagnetic forces. When a RADIO FREQUENCY (RF) POWER is applied to a gas within a chamber, a plasma is created. This plasma is made up of (for this argument) ions (positively charged particles), as the alternating current (AC) of the RF changes polarity the ion is repelled and attracted at the same time. Hence, the ion is moving back and forth. The distance that the ion travels is dependant on the frequency of the RF. The ions (in the proximity of the substrate in the chamber) collide with the substrate and impinge on the surface (removing material in a microscopic sand blasting fashion). This would constitute a physical etching process (no reactive etching taking place).

REACTIVE ION ETCHING (RIE) includes the same process as physical etching with the addition of REACTIVE CHEMICAL GAS SPECIES being selected to react with the material (substrate materials) to be etched. The main goal here is to have a chemical reaction occur with the material being physically removed in order to form an innocuous gas that can be easily pumped away. The additional bonus here is that RIE usually produces much higher etching rates than can be achieved with just simple physical etching. A good example of RIE is the process of removing resist (which is a hydrocarbon), oxygen is excited in a plasma to physically impinge on the surface of the resist and strip off the carbon atom which reacts with the oxygen to produce carbon dioxide and is pumped away.