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enlightening spectroscopy

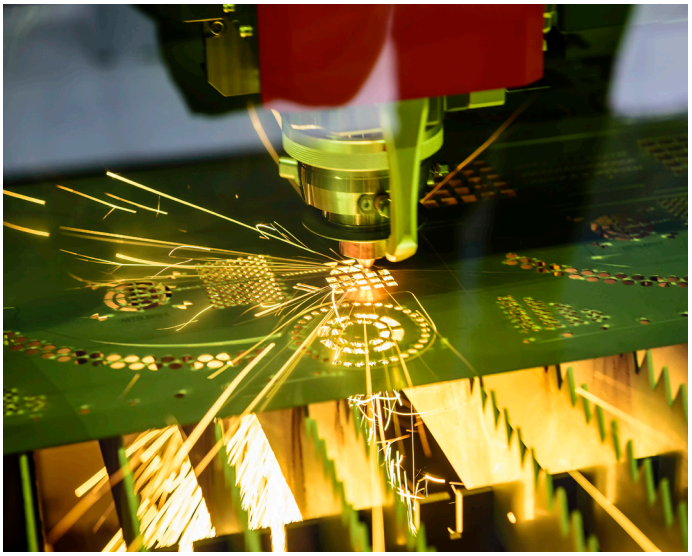
APPLICATION NOTE:
OPTICAL EMISSION SPECTROSCOPY IN THE FABRICATION OF INTEGRATED CIRCUITS

Techniques

- Plasma/ OES

Keywords

- Optical Emission Spectroscopy
- Plasma Diagnostics
- Integrated Circuit Fabrication
- Laser Etching

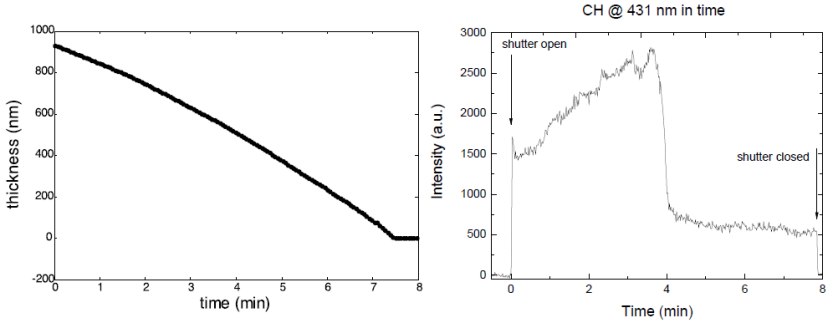


Introduction

Plasma processing is one of the most widely used techniques in modern electronics manufacturing, particularly when it comes to the fabrication of integrated circuits (ICs) and other types of microelectronics. Many large-scale ICs can contain as many as 400 different individual layers, and to build such complex structures each layer typically requires both an epitaxial growth and a plasma etching step. For proper functionality of the IC, it is critical during the etching process that the material from the newly applied layer being etched is removed completely without damaging the subsequent layer below. To make the process even more difficult, plasma etching must be performed under vacuum to prevent deposits of unwanted contaminants. Luckily, during the ionization process, vast amounts of energy are transferred to the ionized material, which results in the release of massive amounts of light.

Exploiting Changes in Energy State

This emission of photons results from the atoms being first excited to a higher electronic state, and then spontaneously dropping back down to the ground state. During the process, since the total energy is conserved, the emitted photons must have an energy equal to the difference between the excitation state and the ground state. The amount of energy transferred in this process is a unique property of the particular species of atom undergoing the transition. Since the frequency of the light, and therefore its wavelength, are directly proportional to the energy of the photon, by collecting the emitted light and measuring its spectrum, it is possible to determine which elements are present. This technique, known as optical emission spectroscopy (OES), gives process engineers the ability to monitor the plasma etching process and detect the endpoint when a layer is completely removed. By providing this real-time monitoring capability, IC manufacturers can fully automate the etching process, without fear that they will over or under etch the layer. Figure 1, courtesy of Professor Richard van de Sanden's Plasma and Materials Process (PMP) group at the Eindhoven University of Technology, shows an example of this process where the 431nm CH line was monitored during the etching process by collecting the emission and coupling it into an Avantes spectrometer via a fiber optic cable. Additionally, OES has the intrinsic benefit of automatically notifying the user when they have reached the previous growth layer by the appearance of spectral lines corresponding to the layer below.



Courtesy of Richard van de Sanden and the Eindhoven University of Technology

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