Materials & Chemicals

Method for Improving Plasma Processes by Controlling a Voltage Waveform

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WARF: P06468US

Inventors: Amy Wendt

The Wisconsin Alumni Research Foundation (WARF) is seeking commercial partners interested in developing an automated method providing improved guidance of energetic ions to substrate surfaces, primarily to enhance the efficiency of plasma processes for the fabrication of integrated circuits.

Overview

The semiconductor industry fabricates integrated circuits (IC) through a series of plasma processes that involve etching lines and spots, as well as depositing thin films of materials and modifying surfaces. As the industry evolves it has continually been pushing the limits of current processing controls in terms of feature size and material composition.

A primary feature of plasma etching is the etch directionality resulting from positive ions bombarding the substrate at a normal rate. For commercial IC fabrication to be successful, high etch rates, etch anisotropy and high etch selectivity between materials must be achieved with minimal damage to the substrate. All IC materials are sensitive to the ion bombardment energy, in addition to ion flux, gas phase chemical composition, substrate temperature and other factors. Constant development of new materials and methods to reduce device dimensions in the advancement of IC performance has lead to further constraints on the etching processes.

In typical plasma processes used to manufacture ICs, the ion energy is coarsely controlled by the voltage waveform that is applied to the substrate electrode, resulting in a broad ion energy distribution function. This unrefined method limits the ability of the plasma process to improve etch selectivity. To enhance the etching process, a more accurate and reproducible method of controlling the ion bombardment energy is needed.

UW-Madison researchers previously developed a system implementing a manual method for controlling the ion bombardment energy (see WARF reference number P00055US).

The Invention

A UW-Madison researcher has now developed an improved algorithm that significantly enhances plasma etching through an automated process that modulates a voltage waveform applied to the substrate material until the optimal bombarding ion energy distribution is achieved.

To control the ion energy distribution, the inventor used a programmable waveform generator in combination with a power amplifier to tailor the waveform shape of the radio frequency (RF) bias voltage applied to the substrate during processing. The technique works by introducing a periodic bias voltage to the semiconductor substrate through a direct current (DC) blocking capacitor, which has a waveform comprised of voltage pulse peaks.

A fast Fourier Transform (FFT) of the substrate waveform is compared, one frequency at a time, with the FFT of a desired "target" waveform, to determine adjustments needed at the waveform generator. An inverse FFT then yields the waveform generator output. It is

repeated until the substrate waveform converges to the targeted shape, providing a quick systematic method for producing an arbitrary distribution of ion energies at the substrate.

This iterative procedure is vital to making the system, previously done manually, fully automated. It has been verified for several target waveform shapes.

Applications

- Fabrication of integrated circuits

Key Benefits

- Iterative procedure speeds up the target waveform, making it more efficient and user friendly.
- Modulates the substrate voltage waveform to achieve the appropriate energy distribution of bombarding ions on the substrate to increase etch selectivity
- Provides a commercially viable method for improving the quality of deposited films in plasma processes
- Improves etch selectivity, film quality and the profiles of etched features

Additional Information

For More Information About the Inventors

- Amy Wendt

Related Technologies

- For more information about the inventor's previous technology for improving plasma-assisted etching of semiconductor materials, see WARF reference number P00055US.

Tech Fields

- Materials & Chemicals : Other materials & chemicals
- Semiconductors & Integrated Circuits : Design & fabrication

For current licensing status, please contact Jeanine Burmania at jeanine@warf.org or 608-960-9846