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WHITE PAPER

LPS 2500 DF Linear Source for Wide Format Etching and Deposition for the Solar and Semiconductor Industries

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Abstract

Flexible electronics is evolving to mean different things to different people. OLED displays with breathtaking resolution, RFID devices for tracking goods on plastic sheets, solar cells on thin metal substrates, just to name a few. As the technology advances the need to build individual layers similar to semiconductor wafer processing will be needed. Impressive advances have been made using imprint technology that will drive down the cost of lithography for wide format processing. Once established, the need to etch or remove materials like dielectrics and metals will be required. Today wet etching provides the least expensive method for most of these etches, but the environmental cost of disposal of the chemicals that are used, will necessitate a cross-over to plasma etching for most applications. The reasons from a technical standpoint will have to do with controlling etched patterns to eliminate the undercutting that wet etches produce. Smaller, faster devices require smaller geometries, so shrinking devices becomes inevitable.

Etched In Time, Inc. (EITI) has developed a new type plasma reactor to fulfill these etching needs. In conjunction with FlexTech Alliance, EITI has completed the design, assembly, and testing phase of a contract to produce a wide format plasma etcher. An active source width of 370 mm was built to accommodate a 370 mm x 470 mm sized panel. The system is scalable to provide at least a meter of plasma etch width, with no changes to the original design. The etch module controls all operations of the plasma. Power for high and low frequency generators, gas flow for 5 mass flow controllers, pressure control via throttle valve, and computer operational control allows simple retrofitting to any number of OEM web based or R2R systems.

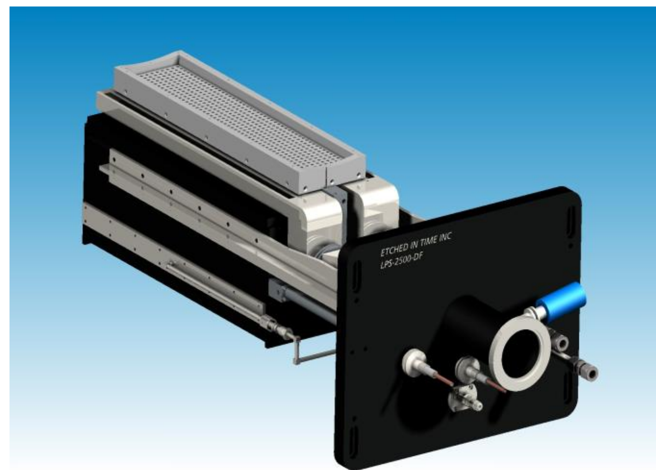
Plasma etching of various metals and dielectrics has been used in the construction of semiconductor devices for a long time. Originally, the plasma field was generated in a large vacuum chamber and directed toward silicon wafers that were arranged in boats, to maximize the amount of wafers that could be processed at one time. This “Barrel Etcher” configuration was good for removing resist or surface treatment to enhance layer adhesion, but lacked good etch uniformity and suffered from slow etch rates. The Barrel Plasma system gave way to single wafer etching, using diode or parallel plate configurations in the early 1980’s. The advantages of single wafer etching soon became a standard in the industry for the etching of such films as silicon dioxide, silicon nitride, aluminum, and many other films used in the construction of IC’s. Control of gas flow, chamber pressure and radio frequency energy allowed for controlled removal of various films, while endpoint detection systems made possible the precise removal of films being

etched. The obvious disadvantage of these single wafer etchers was the lack of volume through a particular process step. The single wafer etcher evolved into platforms that allowed multiple individual chambers to be configured onto a “Cluster Platform” for enhanced throughput. This type of reactor platform is in common use today at most leading manufacturer’s fabs.

Solar cell manufacturing is evolving with new innovations to improve the overall efficiencies of each cell produced. Unlike semiconductor wafers, where many individual dice or chips are produced on a single silicon wafer, making the wafer a very valuable commodity, solar cells are essentially one chip or device per wafer. This necessitates equipment and processes that have much higher throughputs and lower costs, just to be competitive. Equipment must make a paradigm leap in evolution from the single wafer approach, to something that can accommodate much greater productivity at the lowest possible cost to the solar cell manufacturers. This next generation plasma etcher requires innovation and new thinking to meet these expectations.

Introduction of the Linear Plasma Etch Source

The basic concept for the Linear Plasma Etch Source consists of two principals. The first is to build a rectangular parallel plate diode system, similar to the single
wafer etchers described previously. By designing in proper control of gas flow, pumping scheme, electrode spacing, and other variables, a large active etch area can be utilized. An estimated area of 150 mm x 2000 mm will create a large surface area of plasma capable of etching up to (10) 7-1/2”x 7-1/2” solar cells at a time. Processes such as Texturizing, PSG Oxide etching, Silicon Nitride etching or organic removal can be accomplished with this configuration.



The second requirement is to integrate moving up to 10 solar cells through the reactor at the same time, to take advantage of this large area etching scheme. The purpose of this movement is two-fold. First, to take advantage of inherent high etch rates of the Linear Source, speed control of the solar cells is adjustable horizontally through the plasma zone. The second advantage with this type of

movement allows for exacting etch uniformity or removal of the film being etched. Initial testing has shown that a 5% 1 sigma uniformity is readily obtainable. This type of Linear Plasma Etch Source for non-flexible silicon solar cells also lends itself to flexible substrates such as plastic or metal foils. These types of substrates are commonly used in reactors that can process hundreds or thousands of feet of material at one time since they are processed as a roll. These Roll to Roll systems control the speed at which the film is produced, which is similar to the non-flexible substrates described previously. Depending on film thickness to be etched, multiple Linear Sources can be employed to maximize the amount of material to be etched in the shortest amount of time, thereby increasing the productivity of the system many fold.

Process results-Linear Etcher

- High Speed Process (SF_6+He)
- Rate: 5035 angstroms/min Uniformity 2.8% 1 sigma
- Medium Speed Process (SF_6+He)
- Rate: 2917 angstroms/min: Uniformity 1.7% 1 sigma
- Low Speed Process (SF_6+He)
- Rate: 1009 angstroms/min: Uniformity 1.9% 1 sigma
- High Selectivity Process (SF_6+He+CHF_3)
- Rate: 2022 angstroms/min: Uniformity 3.1% 1 sigma
- SiO_2: Photoresist Selectivity: 3.5:1
- Sidewall slope: 82 degrees with no undercut of oxide

The Linear Source described for etch applications also lends itself to high volume PECVD Silicon Nitride, with some modifications. The added increase in productivity can be gained by employing the same rectangular electrode method described in the etch section previously.

This application is being actively pursued by EITI so please contact us if you would like more information.