SEMICONDUCTOR ENGINEERING

More Reactive, Less Warming

Molecular fluorine for CVD chamber cleans.

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As mentioned in Part 4 of Semiconductor Engineering's series on fab sustainability, molecular fluorine is one alternative to PFCs or NF_3 for CVD chamber cleaning in the integrated circuit and flat panel display industries. It has a number of advantages relative to NF_3: an unstable, highly reactive molecule, F_2 breaks down easily and has no global warming potential.

When NF_3 is used, atomic fluorine is still entirely responsible for the cleaning reaction. The nitrogen is not necessary, and so F_2 can serve as a direct replacement with minimal process changes. In fact, F_2 is more effective because it yields more atomic fluorine per unit of input gas. Since less energy is needed to break down the F_2 molecule, less energy is consumed in the cleaning process.

On the other hand, F_2 is both more toxic and more reactive than NF_3, making it more difficult to handle and transport. Transport and cylinder handling are the riskiest operations for any gas. Since F_2 was introduced, on-site F_2 generation has established itself as a safe, cost-effective alternative.

In a paper presented at the 2016 ASMC, Linde Electronics' Jean-Charles Cigal explained that F_2 is generated by electrolysis of anhydrous HF dissolved in a molten potassium salt electrolyte. If power to the generator is cut, either in an emergency or because of extended idle time, fluorine generation ceases. (See **Figure.**) The byproducts of the reaction — hydrogen and fluorine gas — are collected at the anode and cathode, respectively. After dilution below the 4% explosive threshold, the hydrogen is routed to the fab scrubber, which removes any traces of HF before releasing the hydrogen to the atmosphere. Similarly, the F_2 is purified, compressed, and routed to the process equipment.

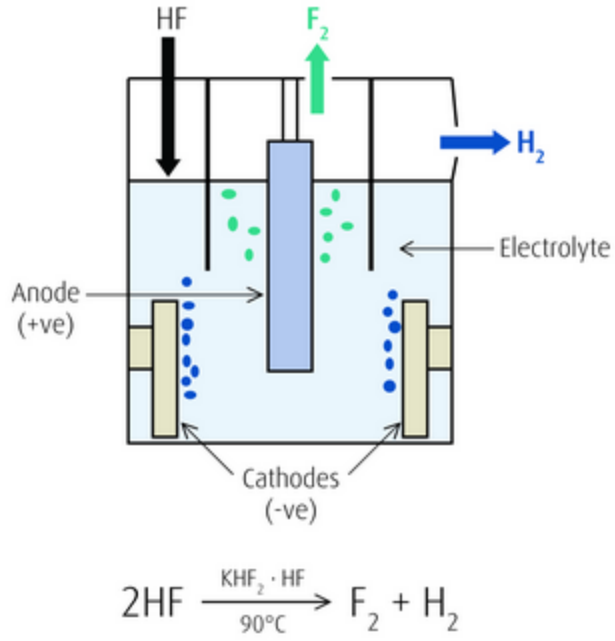

Figure 1: Fluorine generation by electrolysis of HF. Image courtesy Linde Electronics

Paul Stockman, head of market development for Linde Electronics, said that both fab-scale and smaller equipment-scale generator units are available. Both minimize the amount of molecular fluorine present in the fab. For example, Stockman said, a large display customer using over 100 metric tons of fluorine per year would typically have less than 50 kg on-site at any given time, along with a few tons of liquid HF feedstock.

As previously noted, greenhouse-friendly etching chemistries are still an open challenge for the industry. For chamber cleaning, though, F_2 appears to achieve good performance without the problems of either PFCs or NF_3.

Tags: CVD FPC Linde Electronics NF sustainability

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