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Filtration Solutions

Advantages of Carbon in Broad-Spectrum Chemical Filtration for Lithographic Processes

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ABSTRACT:
Contamination of lithographic processes by ammonia is well understood, well documented, and well controlled; however, there are other contaminants that can negatively impact the lithographic process. Recently, some of these have been shown to originate from the surface of the photoresist itself. Good filtration can control of these and other contaminants.

This paper discusses the filtration mechanisms associated with physically adsorptive, chemically adsorptive, and ion-exchange filtration media, and the advantages of choosing a broad-spectrum media to protect the lithographic process.

Lithographic process predictability and repeatability are increasingly important and are increasingly at risk as the number of variables that are exogenous to the process increases. One broad category of variables is gas-phase contamination, which can be introduced by human workers [1], other chip-making processes [2, 7], fab construction materials [3, 8, 18], and the environment outside the fab itself [4]. Gas-phase contamination from exogenous sources is particularly insidious, because it is not constant over time: one-time or periodic events in other areas of the fab or in the outside environment can have a grave impact on the process or tools [5]. Additionally, recent research has shown that the actinic process itself can cause potentially damaging off-gassing from the surface of the photoresist [6].

Contamination events that cause process excursions can easily go undetected; although a process excursion may be noted, the excursion may pass without identification of root cause or prevention of recurrence. As a result, on-going, periodic process excursions can be expected. The effect of many of these exogenous variables remains largely unknown, undocumented, and unquantified. But it is logical, based on the extensive data about the effects of gas-phase contamination, that many process excursions can be traced back to contamination events happening in and around the fab. Some compounds that are known to cause process and yield problems are organics [2, 17], NMP [21], boron compounds [23, 27], and organophosphates [24-26].

One approach to mitigating the effect of contamination events is the installation of adsorbent filters, which can control the gas-phase contamination levels inside lithography tools [9, 19]. Filters are either installed in an "open loop" or a "closed loop" configuration, as shown in **Figure 1**. The contamination level inside a closed loop process tool, as a function of time, is shown in **Figure 2**. Filters for this application generally contain either ion-exchange media or adsorbent media. If it is accepted that much of the source nature and mechanism of the contamination is not fully understood then a filter that has the capability to remove both the expected contaminants as well as the unexpected is desirable.

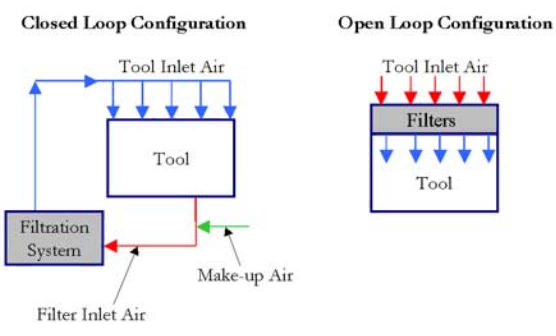
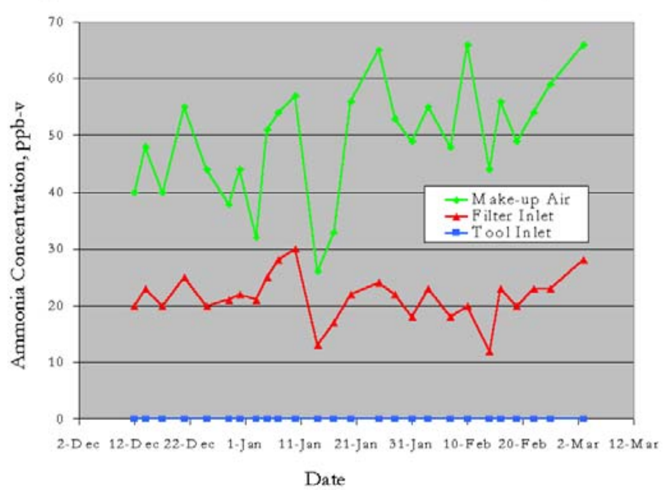


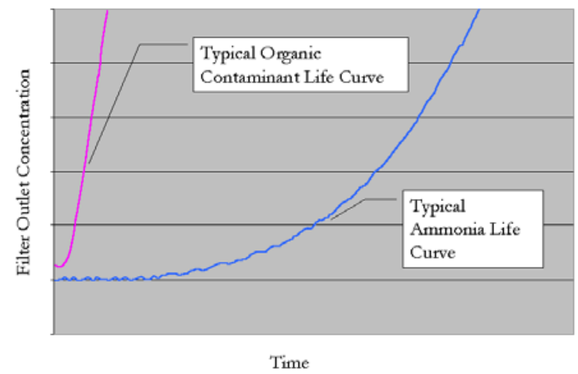
Figure 1: Open Loop and Closed Loop Filtration Configurations

Figure 2: Control of Ammonia Level with Adsorptive Filters



A common ion-exchange media frequently found in the fab looks like pleated membrane. It is also available in granular or powdered forms [10, 12]. Commonly called a “Strong Acid Cation” resin, the polymer-based media has a special chemistry giving it a strong affinity for basic contaminants (such as ammonia and some amines) [11]. Many gas-phase contaminants are not amines, but are organic or acid gases. As a result, there are contaminants that would not be effectively removed by a Strong Acid Cation ion-exchange media. **Figure 3** shows the relative life of a Strong Acid Cation filter media when exposed to ammonia versus an organic contaminant.

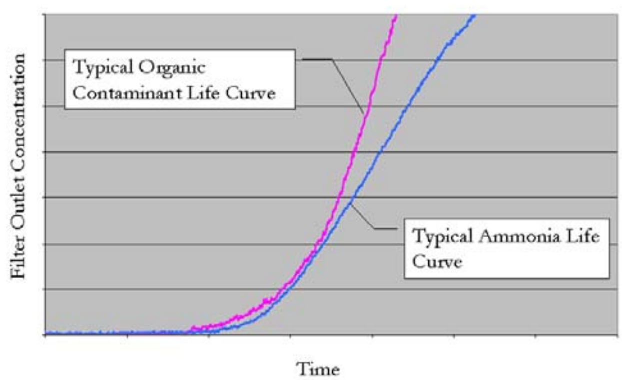
Figure 3: Ion-Exchange Media Performance on Ammonia and Organic Contaminants



An optimal solution, carbon-based adsorbent filters, can offer a broader spectrum of control, by taking advantage of two distinct adsorptive processes: physical adsorption and chemical adsorption. Physical adsorption is the mechanism by which organic contaminants are removed from an air stream. Through van der Waal’s forces a contaminant is attracted into, and retained by, the pore structure of the adsorbent media [13]. This mechanism is very effective for organic contamination removal [14].

Chemical adsorption is a mechanism by which smaller, lighter contaminants (those that are not readily physically adsorbed) can be removed from an air stream [15]. The media is chemically impregnated, meaning that an impregnant is deposited onto the surface and into the pore structure of the media. The chemical impregnant is then available to react with passing gas-phase contaminants and bind them to the media surface [16, 20]. One example of this is the use of an acid impregnant to remove ammonia and other bases from the air stream. Choosing an impregnant is an important part of the design of an adsorbent filter media. The preferred impregnant will react quickly with the targeted contaminant, will be easily and readily deposited onto the media surface, is safe for human contact, and will not off gas from the media matrix. Some potential acid impregnants will meet all of these criteria, and others will not. For example, a carbon filter impregnated with phosphoric acid does not meet the criteria because phosphoric acid, when solvated in water, can occur in the gas phase at room temperature. This leads to concerns about phosphoric acid contamination originating from the filter media in a 40% humidity environment. Using an acid impregnant that is a solid at room temperature minimizes concerns related to off-gassing. **Figure 4** shows the relative life of an impregnated, carbon-based filter media when exposed to ammonia versus an organic contaminant.

Figure 4: Carbon-based Media Performance on Ammonia and Organic Contaminants



Some kinds of filters may be very good at a single targeted contaminant (such as ammonia), but they will not offer a broad spectrum of contamination control. Given the unknown and variable nature of contamination, broad-spectrum filters are better able to reduce contamination caused by exogenous variables. A single carbon-based filter can accomplish both the physically adsorptive and the chemically adsorptive processes that are required to protect the lithographic process and tools from exogenous contamination excursions.

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