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Contaminant particles removal by negative air ionic cleaner in industrial minienvironment for IC manufacturing processes

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ABSTRACT

This study was carried out in a closed test chamber under natural decay, negative ionic air cleaner application, as well as air mixing mechanism with negative ionic air cleaner. Among three operation modes, the air mixing mechanism with negative ionic air cleaner can reduce particles better under the flow field condition. In the air mixing, especially vigorous one (5 ACH (Air Changes per hour)), enhanced the air cleaning effect. The highest removal efficiency was measured at a height of 0.6 m from the floor and it was decreased substantially with an increase in height. The relative effectiveness of negative ionic air cleaners was predicted to decrease with an increasing particle size. We also found that there was a limited horizontal diffusion of ions. The empirical curves fit based for the concentration gradient of NAI (Negative air ionization) generated was developed for estimating the NAI concentration with different heights and distances from the source of negative ionic air cleaner discharge.

1. Introduction

Modern semiconductor electronics requires fast devices operating at smaller amounts of power. This requires the scaling down of typical device sizes. Advances in fabrication technology have led to a shrinking of the minimum device feature size smaller than submicron dimensions in recent years. Very large scale integrated circuit (VLSI) devices such as the current generation of 16 megabit DRAM (dynamic random access memory) have typical device feature sizes on the order of 0.5 μm. Also more than half of IC (Integrated Circuit) processing now occurs in the back end of the line where CVD (Chemical vapor deposition) reactors, PVD (Physical vapor deposition) equipment and plasma tools are used. In CVD and plasma tools, gas phase nucleation can become a potential source of sub- 0.1 micron particles. As the dimensions of device shrink, reducing the particle contamination becomes more important. Usually, as the limit of size of particle influences the device yield shrinks, the density of particles above the limit will increase exponentially.

Due to the decreasing critical dimension of IC patterns, the semiconductor products become increasingly sensitive to small particles that require an especially clean environment. Cleaned air is supplied directly to the manufacturing process for the removal of particles. The minienvironment is the most cost-effective means that can provide extremely clean environment for IC manufacturing rather than a ballroom cleanroom. Minienvironments, often termed "separative devices," have been gaining popularity as a way to provide effective isolation for critical contamination control. The purpose of using minienvironments is either to protect contamination-sensitive products or manufacturing processes by isolating them from the ambient environment and workers, and to protect workers or their environment from exposures to hazardous contaminants by isolating the products or processes, or both [1,2].

Numerous techniques have been developed to reduce the presence of particles in cleanrooms in IC manufacturing facilities. The basic principles used for particle eliminating techniques include HEPA (High Efficiency Particulate Air) filter, ULPA (Ultra Low Penetration Air) filter, air shower, and others. Besides these methods, negative ionic air cleaners have also received increasing attention and are presently being used for removing particles from cleanroom air. Negative air ionization has the potential to reduce concentration of particles in cleanrooms. The effect appears to result from ionization of particles, causing them to settle down more rapidly. Settling tends to occur on horizontal surfaces, especially wafer surfaces, and generally in the area near and around the ionization unit. Ionization may enhance agglomeration, creating larger particles out of smaller particles, thereby increasing the

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