A study was performed to evaluate the relative performance of three "advanced technology" cleanroom jumpsuits for use in a Class 10 wafer fabrication facility. Simulations of actual operator activity were used in the evaluation, and performance was rated through airborne particle counting as well as witness wafer surface measurements. A dramatic reduction in particles was observed when operators wore garments laminated with an expanded PTFE membrane, without a significant loss of operator comfort.

INTRODUCTION

As the geometries of integrated circuits get smaller, more effort is needed to keep the environment around in-process wafers clean. This requires improved methods of protecting the product and environment from human contamination. One method of keeping the environment clean is to use cleanroom garments which offer an effective barrier to wearer-generated contamination and are inherently nonshedding.

The purpose of this study was twofold: 1) to determine the effect of cleanroom garments on particulate contamination at the wafer processing level; and 2) to evaluate the barrier/shedding properties of cleanroom garment fabrics.

GARMENT MATERIALS

Three advanced-technology jumpsuits were chosen for the test: 1) custom-designed 100% polyester herringbone; 2) expanded PTFE membrane laminated on polyester; and 3) coated spunbonded polyolefin. The first two garment types were laundered per manufacturers' specifications prior to use; the third type was received sealed from the manufacturer. The same type of headgear and boots were used with all three types of garments. The headgear used was a full-face "bubble hood" with a recirculated airflow system and a HEPA-filtered exhaust. The fabric portion of the hood was replaced with a PTFE-laminated piece, and the nonfabric portions were thoroughly cleaned with deionized water. This highly efficient hood was used to eliminate contamination from the head area during the study. The boots used for the study were a knee-high, PTFE-laminated upper with a molded sole. They were worn over the lower leg of the jumpsuit in all cases. Boots were changed with each garment change.
EXPERIMENT LOCATION AND EQUIPMENT

The area used for the study was a very clean, low-traffic area of a Class 10 cleanroom. The tables and associated areas were wiped with isopropyl alcohol immediately prior to each series of tests. Initially, there were three simultaneous activities, and a fourth activity was added later. Particles from the first, third, and fourth activities were counted with an optical aerosol particle counter with a lower detection limit of 0.3 micrometer. The readout panel of the particle counter was facing away from the participants to prevent feedback on their activities. The first and second activities each utilized six bare silicon witness wafers, which were analyzed using a laser surface scanner before and after each test. With a lower detection limit of 0.2 micrometer, all precounts were below fifty particles per wafer. The airborne particle count at the wafer processing level for the twenty-four hours preceding the experiment averaged less than one particle per cubic foot of air, 0.3 micrometer and larger. The adjacent areas of the cleanroom were occupied for eight of those twenty-four hours, indicating good isolation of the test area. Air currents within the area of the test were characterized with liquid nitrogen vapors to assure that the measurement points were in the path of the airflow from the operator.

TESTING PROTOCOL

Three wafer fab operators were the subjects for the testing. The operators wore the same type of garment for each series of three activities to minimize residual contamination effects. One activity was a two-hand reach, another was a one-hand back-and-forth motion, and the third activity was walking. The activities took place simultaneously, with enough distance between their locations to eliminate cross-contamination effects. Each garment was subjected to the same series of tests.

The particle counters were operated during the break time between each series of activities to verify cleandown of the area. The witness wafers were set in place immediately prior to the beginning of each series of activities and collected immediately after each test. They were transported in a closed wafer storage box, along with nine control wafers which had been left in the open box during the test.

After instructing the operators regarding test conditions and demonstrating the activity movements, instructions were given on how to don the garments properly. All garments were taken directly from the packages. The operators wore clean vinyl gloves while donning the garments, then changed to fresh vinyl gloves for the test. The operators were asked to briefly demonstrate each of the activities to verify that they understood the procedures. The operators were then instructed to step back from the test station until the cue was given to start the activities.

The first three activities took place for a period of fifteen minutes each. Each movement was cued by a metronome to keep a steady pace throughout the test. The first two activities were performed at plastic-laminate-covered tables; the third and fourth activities took place in an open area of the bay.

For the first activity (see Figure 1) there were three points marked on the table: one directly in front of the operator at arm's length (averaged among the three operators); another to the right of the operator also at arm's length; and a third equidistant on the left. The operator stood at the edge of the table, not leaning against it but just touching it. The activity, which simulated wafer carrier movement, was