CLEAPART-100 to monitor particle rate deposition in laser cleanrooms
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Keywords: deposition, resuspension, particles, CLEAPART-100, laser

Abstract.
Particle fallout in cleanrooms is a primary concern for industries manufacturing critical products with surfaces highly susceptible to particulate contamination. Limited research has been conducted to measure the deposited particles in cleanrooms. In the frame of the Laser MegaJoule (LMJ), this paper gives the first results of deposited particles measurement around the transport mirrors obtained thanks to a real-time and innovative device: CLEAPART-100. The CLEAPART-100 detects the same contamination event as optical counters do. The main interest of the CLEAPART-100 is that it follows the dynamic behavior of the deposited particles higher than 5 µm with resuspension of part of them.
1. INTRODUCTION

Sediment particle contamination is contamination that poses a risk for the transport mirrors of the Laser MegaJoule – LMJ, in that some of these mirrors face upwards, in a so-called "dust gathering" position. To minimise this risk, teams at CEA-CESTA have developed and qualified a device for measuring particles deposited in real-time: the CLEAPART-100. This article presents the first results of measurements on particles deposited in the ISO 7 transport mirror environment, as well as the results obtained in monitoring airborne particles using a METONE 2.83 l/min optical counter.

1.1. CLEAPART-100

The CLEAPART-100 is an innovative system for counting sediment particles in order to monitor the cleanliness of similar controlled environments. It detects, creates images and classifies deposited particles larger than 5µm according to their size. It is the result of collaboration between CEA-CESTA, the Université d’Aix Marseille and Winlight System (I.Tovena Pecault et al., 2015).

It takes the form of a cube which is compatible with cleanrooms. It has a glass surface where particles are deposited. These are then detected by an optical camera which moves beneath the glass along the X and Y axes (see Figure 1). The principle used involves scanning a reference surface using a high-resolution camera. The measurement takes five minutes and can be repeated continually over several weeks (I.Tovena Pecault et al., 2016 a ; 2016b). The CLEAPART-100 was qualified by comparing the results obtained using the CLEAPART-100 with those obtained by collection on sedimentation targets and analysis under an optical microscope, using an image analysis system designed to count and classify deposited particles (Filtrex® from Microvision). This qualification process showed that monitoring using sedimentation targets significantly underestimated the risk of particulate contamination through the transfer of particles deposited on the targets to, in particular, the target transfer boxes (I.Tovena Pecault, 2017). The results of counting cumulative number of particles per cm$^2$ are monitored graphically in real time for each particle size range (>5, >15, >25, >50, >100µm).

Figure 1: CLEAPART-100 for real-time in-situ monitoring of deposited particles in cleanrooms
1.2. THE LMJ ISO 7 ROOMS

Two classified environments were chosen:

- the branch room E301 which holds transport mirrors (MT2 to MT5) for the upper quadruplet of the first assembled laser line of the LMJ (ISO7).

- the branch room E1a which holds transport mirrors (MT2 to MT5) for the lower quadruplet of the first assembled laser line of the LMJ (ISO7).

The period chosen represents a period of maintenance of the LMJ and subsequent resumption of assembly and laser activities. On the morning of 9/8/17 the nuclear ventilation and recyclers were shut down with operation resuming at about 21:00 hours.

2. RESULTS OF MEASUREMENTS ON AEROSOLS IN ISO 7

2.1. Airborne particles

An optical counter of the METONE type (2.83 l) is occasionally used to monitor aerosols of size >0.3, >0.5, >0.7, >1, >2, >5µm. Figure 2 shows the results obtained in room E1a during the shut-down of the recyclers, then when operation resumes at around 21:00 hours.

![Figure 2: Measurements on aerosols as cumulative concentrations from 0.3µm from 9 to 10/08 in E1a during recycler shut-down](image)

2.2. Deposited particles

Figure 3 shows that during the ventilation shut-down there was accumulation of particles of all sizes, with in particular more than 5118 part/cm² of size >5µm as opposed to 3024 part/cm² before this event. After the recyclers resumed operation at about 21:00 hours, there is pseudo-cleaning of surfaces which occurs for particles with sizes less than or equal to 25µm in room E1a, reaching 4510 part/cm² at 14:20 hours on 10/08. On the other
hand this cleaning of the surfaces is much more marked in E301, as figure 4 shows. CLEAPART-100 operating in calibration mode allows the degree of dust contamination at the start of the experiment to be defined as the reference condition for measuring subsequent dust deposition on the surfaces. In Figure 4, it can clearly be seen that after the recyclers resume operation towards 21:00 hours on 10/08, pseudo-cleaning of the surfaces for all particle sizes took place, except for particles whose size is >= 50 and 100µm.

Figure 3: Deposited particles measured by the CLEAPART-100 (part/cm²) for particles of size >5µm, >15µm, >25µm, >50µm, >100µm in E1a

Figure 4: Deposited particles measured by the CLEAPART-100 (part/cm²) for particles of size >5µm, >15µm, >25µm, >50µm, >100µm in E301

The behaviour of the surface particles therefore differs in E1a and E301. This is confirmed by monitoring the rate of surface particle contamination in E1a (figure 5) and in E301 (figure 6) respectively. We can see that the air movement in E1a results in cleaning of surfaces for particles of size less than 25 µm in E301, and accumulation in room E1a.
3. CONCLUSION

Real-time monitoring of particulate contamination deposited on surfaces using CLEAPART-100 can be used to give warning of critical surface particulate contamination levels before laser beams are produced. A cleaning phase for the mirror surfaces may then be carried out, before a laser firing sequence which could damage the mirror surfaces. During this study we show that following a shut-down of recycler operation, the LMJ cleanrooms remain as ISO 7, but that the levels of deposited particulate contamination quickly become unacceptable. We have also shown that on restart of the recyclers, slight cleaning of the surfaces takes place for all particles of size < 50µm. In a nominal situation, however, over longer operating periods, we observe that surface dust contamination is highly dependent on particle size, on the air movement in ISO 7 rooms and on the positioning of the mirrors in these ISO 7 rooms.
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