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Laser Fumes of fs Laser Processes – Product, Process and Environment Considerations

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Abstract

Laser treatment is increasingly used in material patterning. Avoiding thermal impact is for some of them crucial to achieve high quality products. This requirement let to recent increased utilization of ultra-fast laser processes. The following article investigates laser safety requirements of ultra-fast processes with respect to particle generation, shape and filtration. Especially, particles of ultra-fast processes are significant smaller and have a non-hemispherical shape, which asks for specialized solutions to achieve a long filter life time.

Ablation, Ultra Fast Lasers, Process Control, filtration

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1. Introduction

Advanced laser processes are increasingly utilized in production. The later fosters an in depth understanding of laser fumes, which are a major factor of product quality, machine life and environmental/safety & health considerations. Short pulse laser processes are focused on non-melting preparations. On this bases exciting new applications arise. Starting from hard-glas manufacturing, over thin film photovoltaic patterning to Lithium Ion Battery electrode structuring virtually every advanced technology relies on ultra-short pulse laser processes. [1-6]

2. Experiment

The presented study was performed on a femto second laser with a wavelength of 1064nm [3]. Correlations between type of ablated material, particle size distribution as well as particle concentration have been investigated. Especially, the difference in particle size between steel and plastic has been evaluated.

The … rial processing was captured close to the source and sucked towards a
filt… was determined continuously using an Engine Exhaust Particle Sizer
(EE… in the range from 5.6 to 560 nm. For this purpose a sample was
ana… within the sample are positively charged and move within an electric
fiel… eir charge is transferred. The charge is a measure of particle-surface-
are… bility particles reach different electrometers. Based on current flows
pa… ed. In addition sample where taken from the filter and investigated by
Se…) for analyzing the shape of the particles.

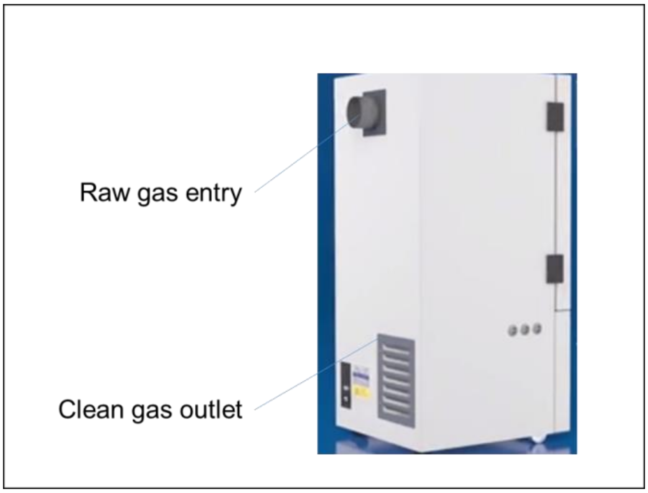

Figure 1: Exhaust- and filtersystem LAS260 for ultra fast plaser processes

The raw gas was filtered using the filter-system „LAS260“, a storage filter with F9 pleat pre-filtration. This pre filter consists of high surface area with a well-defined cross flow to ensure long filter life. A secondary particle filter with the HEPA class H14 ensured cleaning capability to 0,005% of total particle count. Further down the gas stream activated carbon was located to remove eventual reminders of hazardous gases from the laser process.

Additionally, the performance of the filter system “LAS260” was determined. For this the laser was kept in stationary conditions and the particle concentrations in raw gas and purified gas were measured using the EEPS-method.

3. Results and Discussion

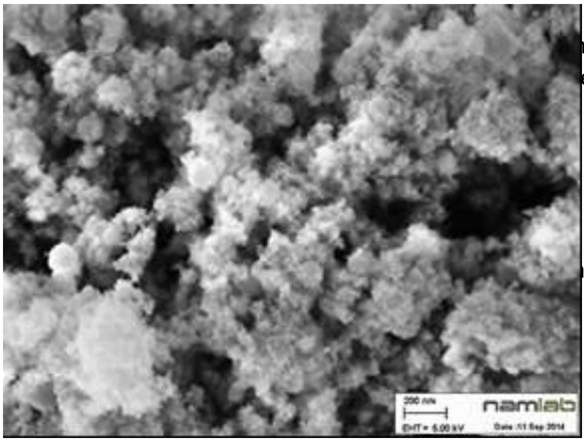

Fig.2: Particles of steel from a fs-ablation process (resolution scale: 1µm)

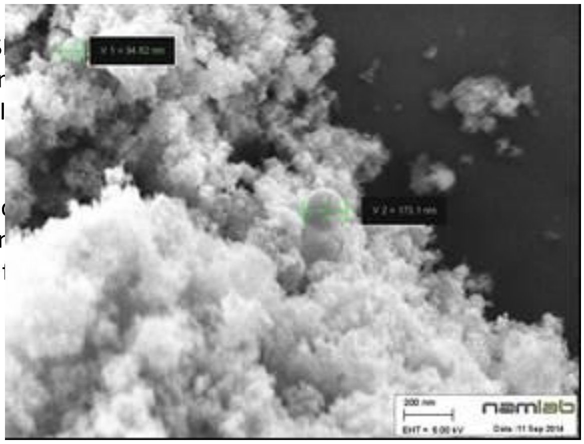

Fig.3: Particles of steel from a fs-ablation process (resolution scale: 200nm)

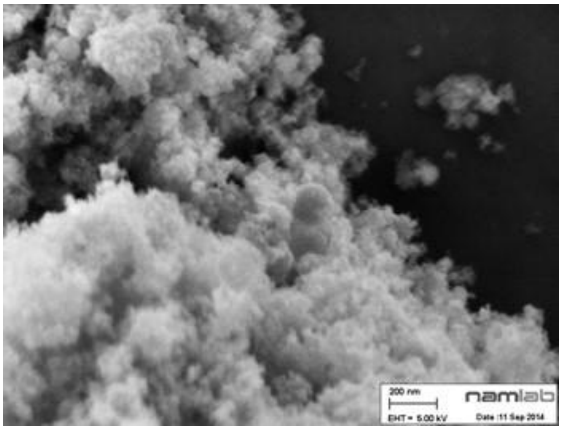

Fig.4: Particles of plastic from a fs-ablation process

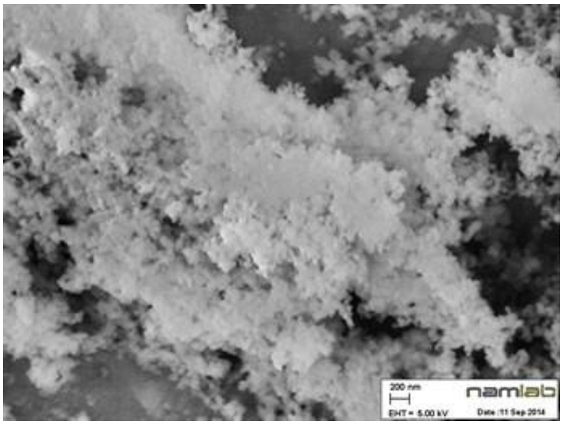

Fig.5: Particles of plastic from a fs-ablation process

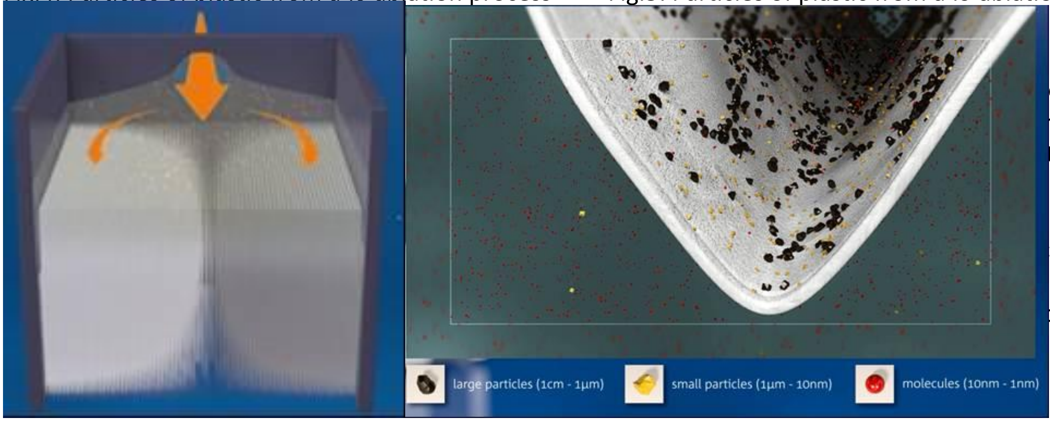

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Figure 6
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Fig.: 6 Filter principle of F9 pre-filtration in LAS260

Figure 7 depicts the measurement results of EEPS during the plastic process. The statistic maximum of plastic particles was at d=90nm with a concentration of 3..4 10^5 particles per cubic centimetre. This value is well above acceptable concentrations for high product quality and operator health. By employing the filter sandwich of LAS60 the clean gas was on the same level as the background signal of the lab with $dN \ll 10^2$ #/cm³. Hence a high quality operation in terms of laser fume is possible.

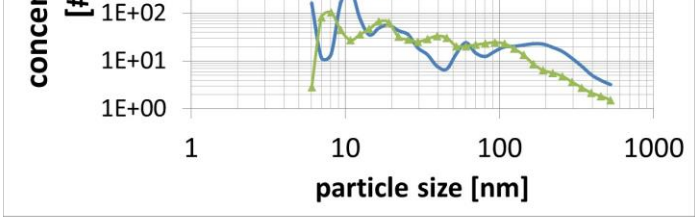

Fig.: 7: EEPS data of raw- and clean-gas during preparation of plastics with an ultra fast laser. Clean gas was filtered by a particle filter system “LAS260”

4. Summary

Ultra fast laser processes, especially in the femto second range have been investigated in terms of particle distribution during the operation. Particle size is found to be in the range of d=50nm…200nm in significantly high concentrations of up to 10^6 #/cm³. By using the new LAS260 with pleat filtration and HEPA post filtration a fractional deposition is the filter of >>99% was demonstrated. For non-cancerous and mutagenic materials the filtered air can be re-circulated in the working environment for saving energy cost

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