Whitepaper

Opus laser used in new instrument to characterise individual aerosol particles

***Abstract**: The **opus 532** laser has been integrated into a commercially available aerosol spectrometer which is capable of trapping airbourne particles for extended periods of time whilst the Raman spectrum and other important parameters are measured to fully characterise the particle.*

Introduction

Aerosols play important roles in everyday life influencing health, both through environmental exposure and the use of technologies such as inhalers for the delivery of drugs to the lungs, fuel injection efficiency in combustion engines and even global climate change. Despite this, their extremely dynamic nature makes them challenging to study as they are continually evolving with time. Defined as a collection of solid particles or liquid droplets dispersed in air, with particle sizes ranging from nanometres to millimetres, aerosols are a unique phase of matter whose characterisation require a combination of measurement techniques.

Although aerosol particles can be analysed with traditional velocimetry techniques, these only offer a small window of time in which to measure the particles' properties; for investigations of particle properties over longer timescales, a particle must be "trapped" (figure 1) to enable manipulation and characterisation, using a highly stable laser beam.

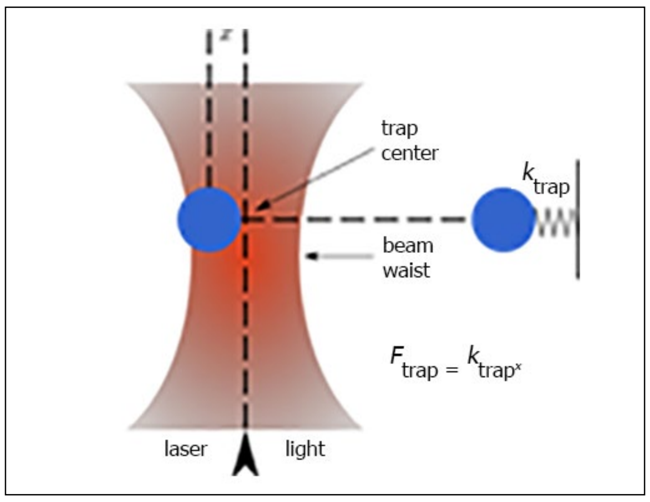

Figure 1: Dielectric objects are attracted to the centre of the focussed beam, slightly above the beam waist. The force applied on the object depends linearly on its displacement from the trap centre just as with a simple spring system

Figure 2: Laser Quantum **opus** laser 532nm up to 6W

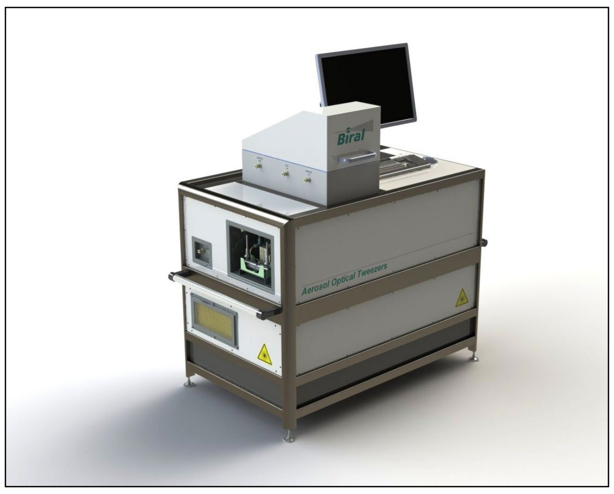

Figure 3: Biral's AOT-100 with built-in spectrometer

Professor Jonathan Reid's group at Bristol University, UK, in collaboration with Biral Ltd, an established manufacturer of aerosol instrumentation, have developed an instrument for characterising individual aerosol particles by first creating an optical tweezers trap using Laser Quantum's **opus 532** laser (figure 2), and then using Raman spectroscopy to characterise the particle.

Based on the gradient forces of focused light acting upon dielectric particles, first reported in 1970 by Arthur Ashkin at Bell Labs, optical tweezers are now utilised in many research institutes as a means of not only trapping individual particles (and live cells) but manipulating them without contamination.

The **opus 532** laser has long been established as an ideal laser for optical tweezing. With a pointing stability of <2µrad/°C and power stability of <0.2% RMS, the **opus 532** is extremely stable, ensuring that particles, once trapped, remain strongly confined as well as enabling the user to repeat their measurements on multiple particles, ensuring a statistically sound data set.

Once trapped, the researchers at Bristol University investigate the properties of single particles using Raman spectroscopy. Photons from the trapping laser light interact with the molecular vibrations of components within the particle and are re-emitted at a different frequency, providing vital information about the chemical makeup of the particle. Indeed, micron-sized aerosol droplets act as high-finesse optical cavities leading to amplification of Raman scattered light at wavelengths commensurate with standing wave resonances within the droplet (known as whispering gallery modes) allowing highly accurate measurements of particle size and refractive index.

Biral Ltd recently launched a commercial aerosol optical tweezer (AOT) named the AOT-100 (figure 3) with integrated Raman spectrometer. This instrument has been designed to be a class 1 laser product and includes the **opus 532** laser. The heart of the AOT-100 is seen in figure 4 and is a compact optical layout, incorporating the **opus 532** as the trapping/excitation source, aerosol chamber and spectrometer. It is capable of trapping particles and determining the size and refractive index, with respective uncertainties of ±0.05% and ±0.1%, as well as chemical composition.

The AOT-100 offers a step-change in the commercially available technology for optical tweezers and will enable researchers to investigate issues from climate change through to drug delivery without the need for in-depth optical knowledge.

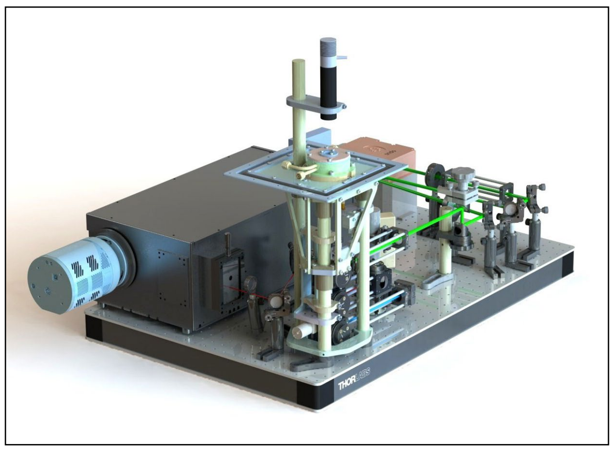

Figure 4: Main optical components of AOT-100

Acknowledgements:
Prof. Jonathan Reid of Bristol University, Dr. Jim Walker of Biral Ltd, Dr. Lawrie Gloster and Dr. Justine Bentley of Laser Quantum Ltd.