Detection and quantification of Carbonaceous Particles in Ambient Air

Dr. A. Stratmann & Prof. Dr. techn. G. Schweiger
Laseranwendungstechnik & Messsysteme
Maschinenbau, Ruhr-Universität Bochum
OUTLINE

- INTRODUCTION
- EXPERIMENTAL
- MEASUREMENTS & EVALUATION
- SOOT RAMAN SPECTRA
- SUMMARY & OUTLOOK
DETECTION OF SOOT IN AMBIENT AIR

• THERMAL ANALYSIS
• EXTINCTION
• FILTER TRANSMISSION OR REFLECTION
• LASER INDUCED INCANDESCENCE
• PHOTOACOUSTIC SOOT SENSOR
• RAMAN SOOT SPECTROSCOPY
PROPERTIES OF Raman SCATTERING

INELASTIC SCATTERING PROCESS

INTERACTION OF LIGHT AND VIBRATIONAL ROTATIONAL MODES

SHAPE AND RELATIVE SPECTRAL POSITION OF RAMAN BANDS DEPEND ON CHEMICAL COMPONENT

ABSOLUTE SPECTRAL POSITION OF RAMAN BANDS DEPENDS ON EXCITATION WAVELENGTH

AMPLITUDE DEPENDS ON NUMBER OF MOLECULES

RAMAN SCATTERING CROSS SECTION IS WEAK
DETECTION AND QUANTIFICATION OF CARBONACEOUS PARTICLES IN AMBIENT AIR

EXPERIMENTAL
DETECTION AND QUANTIFICATION OF CARBONACEOUS PARTICLES IN AMBIENT AIR

SAMPLING & EVALUATION

RUHR-UNIVERSITÄT BOCHUM

EVALUATION

STRATMANN and SCHWEIGER
COMPONENTS OF SOOT RAMAN BAND

CALCULATED RAMAN SPECTRUM OF CARBONACEOUS MATERIAL

D1, 1360 cm⁻¹
LORENTZIAN LINE-SHAPE

G, 1580 cm⁻¹
LORENTZIAN LINE-SHAPE

D2, 1620 cm⁻¹
LORENTZIAN LINE-SHAPE

D3, 1500 cm⁻¹
GAUSSIAN LINE-SHAPE

D4, 1180 cm⁻¹
LORENTZIAN LINE-SHAPE

RAMAN INTENSITY / A.U.

RAMAN SHIFT / CM⁻¹
RAMAN SPECTRUM
SOOT ON FILTER

RAMAN SHIFT / CM$^{-1}$

RAMAN INTENSITY / COUNTS

BACKGROUND

SOOT SPECTRUM

RAMAN SOOT SIGNAL

EVALUATED RAMAN D1 PEAK HEIGHT

RUHR-UNIVERSITÄT BOCHUM
EVALUATION

STRATMANN and SCHWEIGER
RAMAN SPECTRUM
SOOT ON FILTER

CALCULATED RAMAN SPECTRUM

RAMAN D1 PEAK HEIGHT

MEASURED AMBIENT AIR SOOT

RAMAN INTENSITY / A.U.

RAMAN SHIFT / CM\(^{-1}\)

1100

1700

RUHR-UNIVERSITÄT BOCHUM
EVALUATION

STRATMANN and SCHWEIGER
RAMAN INTENSITY VERSUS SAMPLING TIME

PALAS GFG 1000 SOOT FILTER SAMPLING TEST

$R^2 = 0.9977$
REM PICTURES OF FILTER SURFACE

RUHR-UNIVERSITÄT BOCHUM

EVALUATION

NO SOOT
RAMAN INTENSITY VERUS SAMPLING TIME

AMBIENT AIR MEASUREMENT
GREEN BELT OF THE RUHR-UNIVERSITÄT & SUNNY SPRINGTIME WEATHER CONDITIONS

$R^2 = 0.9945$
DETECTION AND QUANTIFICATION OF CARBONACEOUS PARTICLES IN AMBIENT AIR

RUHR-UNIVERSITÄT BOCHUM

SOOT SPECTRA

SOOT RAMAN SPECTRA

STRATMANN and SCHWEIGER
DETECTION AND QUANTIFICATION OF CARBONACEOUS PARTICLES IN AMBIENT AIR

SUMMARY AND OUTLOOK

SUMMARY AND OUTLOOK

RUHR-UNIVERSITÄT BOCHUM

SUMMARY & OUTLOOK

STRATMANN and SCHWEIGER
OUTLOOK

RUHR-UNIVERSITÄT BOCHUM
SUMMARY & OUTLOOK

IMPROVEMENT OF SENSITIVITY

CALIBRATION

FILTER PROPERTIES

IDENTIFICATION OF OTHER COMPONENTS

SIZE EFFECTS

END OF PRESENTATION
Palas GFG 1000 soot sampl. 70 Min. / exp. 180 s

BLACK ACRYLIC CALIBRATION STANDARD EXP. 200 S
MOTORBIKE

RUHR-UNIVERSITÄT BOCHUM

SOOT SPECTRA

MOTORBIKE EXHAUST
YAMAHA XV 1100
EXP. 200 S

BLACK ACRYLIC
CALIBRATION STANDARD
EXP. 200 S

RAMAN INTENSITY / A.U.

1100  RAMAN SHIFT / CM⁻¹  1700

STRATMANN and SCHWEIGER
AMBIENT AIR

RUHR-UNIVERSITÄT BOCHUM

SOOT SPECTRA

BLACK ACRYLIC CALIBRATION STANDARD EXP. 200 S

AMBIENT AIR SAMPLE SAMPL. 100 MIN. / EXP. 120 S

RAMAN SHIFT / CM\(^{-1}\)

1100

1700

RAMAN INTENSITY / A.U.