

Imaging Spectroscopy at Activation of Carbon Dioxide by Atmospheric Pressure Microwave Discharge

Workshop "*Oberflächentechnologie mit Plasma- und Ionenstrahlprozessen*"
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IfU Diagnostic Systems GmbH

Developer, Producer and Distributor of
Fast Optical Emission Spectrometer based on
AOTF (*a*cousto*o*ptic *t*unable *f*ilter)



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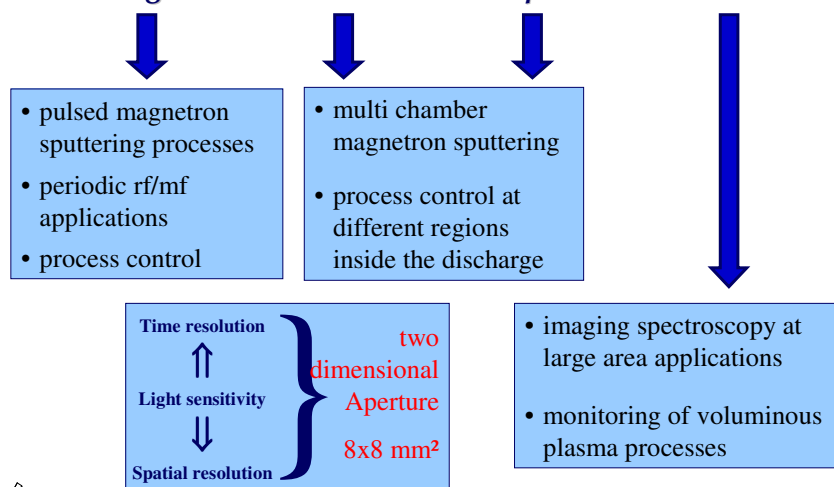
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Emission Spectroscopy

high time resolution - *spatial resolution*



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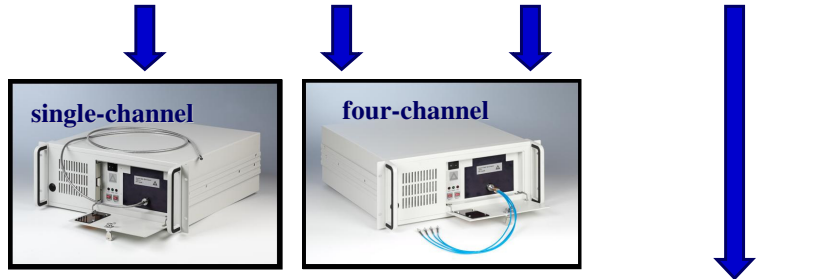
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AOS 4/5 – Emission Spectrometer

fast, robust, high light sensitivity, high wavelength resolution



Technical parameters AOS 4(5)	
spectral range	245 nm800 nm
spectral resolution	0.05nm @ 250nm , 0.5nm @ 800nm
wavelength access	5(1) milliseconds
time resolution in pulse mode	200(10) ns
size	19" rack, height 4



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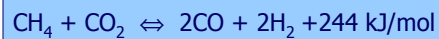
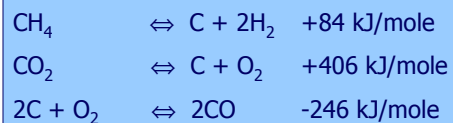
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Motivation

- Green house effect – reduction of Carbon dioxide
- Plasma activation of CO₂
- CO₂ can be used for chemical synthesis



- Optical emission spectroscopy for process control
- Optimisation of homogeneous activation using imaging spectroscopy



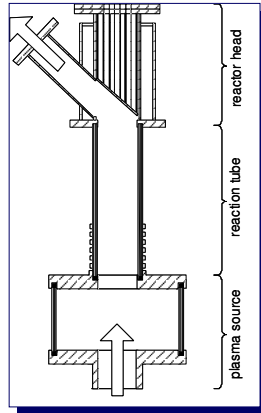
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Plasma activation reactor

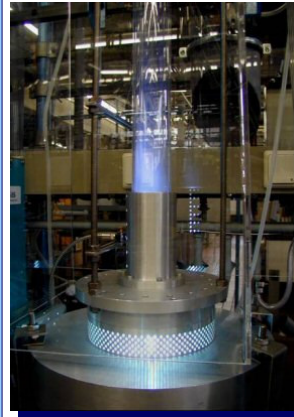


CYRANNUS® I
plasma source
from Iplas GmbH,
Germany

microwave power:
up to 6 kW

flow rates:
about 10 m³/h
(200 m³/h possible
in inefficient mode)

Gas supply:
Carbon Dioxide,
Argon, Methane,
Hydrogen



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Synthesis reactor equipment at the Dortmund University



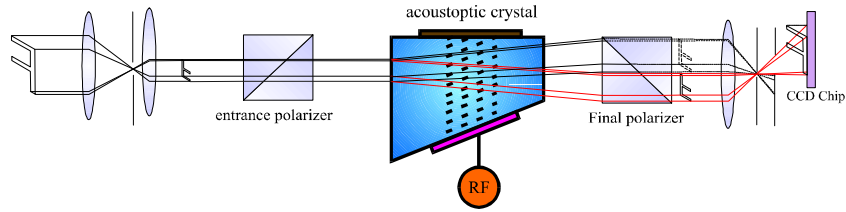
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Optical arrangement - video spectrometer



spectral range	400 nm 800 nm
spectral resolution	0.15 @ 400nm, 0.5 @ 800nm
picture sampling rate	8Hz (120ms/picture)
spatial resolution	40x40 pixels



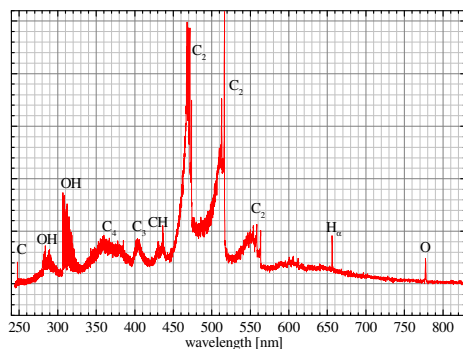
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Typical spectrum of synthesis gas production at atmospheric pressure



Following specimen were found in emission spectrum:

- C – Atomic Carbon,
- C₂, C₃, C₄ – Carbon cluster
- O – Atomic Oxygen (triplet)
- H – Atomic Hydrogen
- OH, CH – Bands



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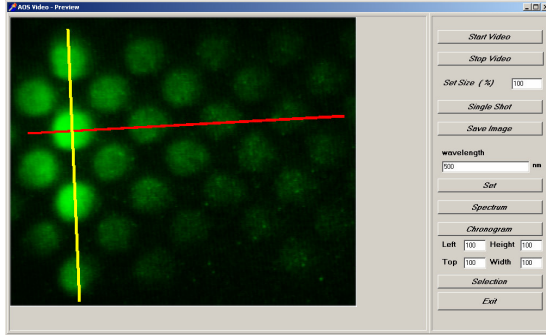
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AOS-Video Software

Intensity distribution inside the plasma source



- Spectrum mode – integration of intensity at selected area for every wavelength
- Chronogram mode – sampling of pictures for selected wavelengths

C2-Emission at 516 nm
Central range of plasma source



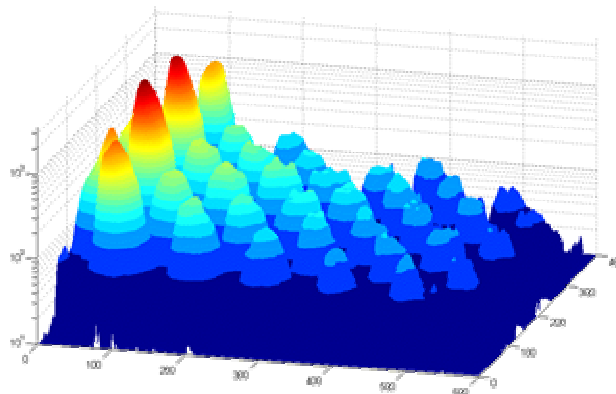
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Intensity distribution of the O-Triplets during the Methane experiments



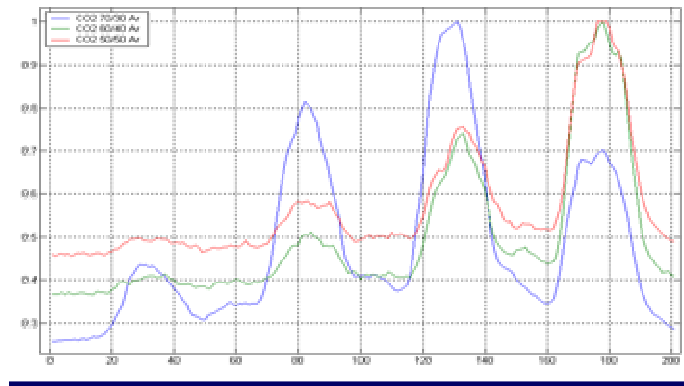
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Distribution of C_2 -emissions in main stream direction at different streaming conditions



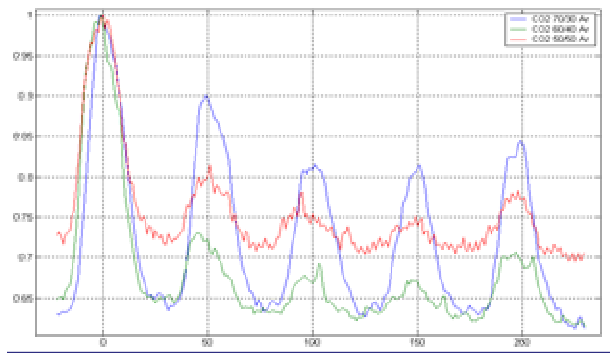
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Radial distribution of C_2 -emissions at different streaming conditions



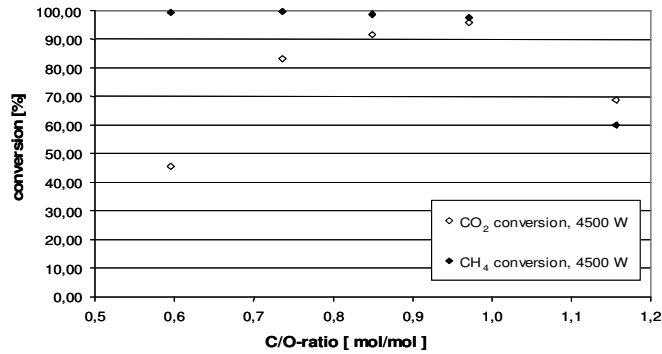
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Conversion of raw material depending on the ratio of inserted C and O atoms at micro wave power of 4500W



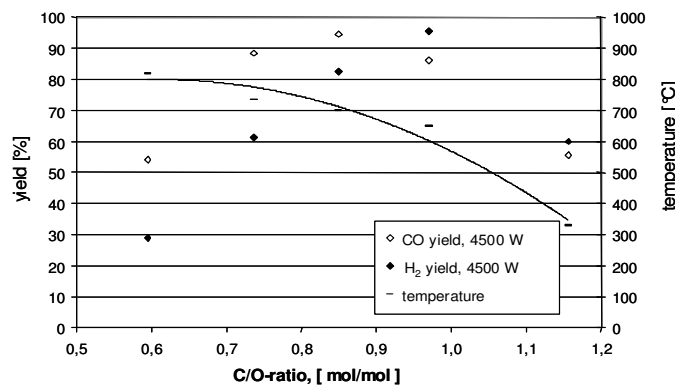
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Yield of conversion products depending on the ratio of inserted C and O atoms at micro wave power of 4500W



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Conclusions

- Plasma activation of Carbon dioxide adding Methane is able to produce synthesis gas,
- Synthesis reactor handles up to 10 m³/h gas flow,
- Time resolved emission spectroscopy is able to optimise the plasma activation process
 - for conversion of raw material,
 - yield of conversion,
 - pre selection of conversion products,
- Acoustooptic imaging spectroscopy – useful method to investigate large area or volume plasma phenomena. .



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Future Work

- Imaging Spectroscopy
 - spatial resolution 100x100 pixels
 - picture sampling rate 40ms/picture
 - extend the wavelength range to UV
- Time Resolution
 - wavelength access: 1ms
 - pulse mode: 10ns
 - periodical application: less 10ns (phase shift method)
- Process Control
 - evaluation of DAC-module
 - AOS-Profibus-implementation



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