Hydrogen production via biomethane reforming in DBD reactor

Mirosław Dors, Tomasz Izdebski, Artur Berendt and Jerzy Mizeraczyk

Centre for Plasma and Laser Engineering
The Szewalski Institute of Fluid-Flow Machinery Polish Academy of Sciences

Introduction

The aim

- Efficient production of hydrogen from biomethane
- Is there any influence of the supply parameters on hydrogen production efficiency?

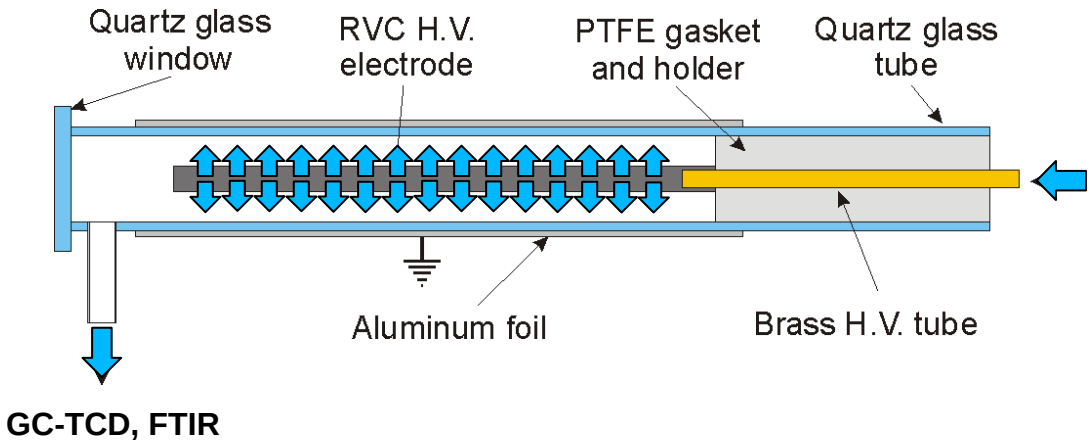
Motivation

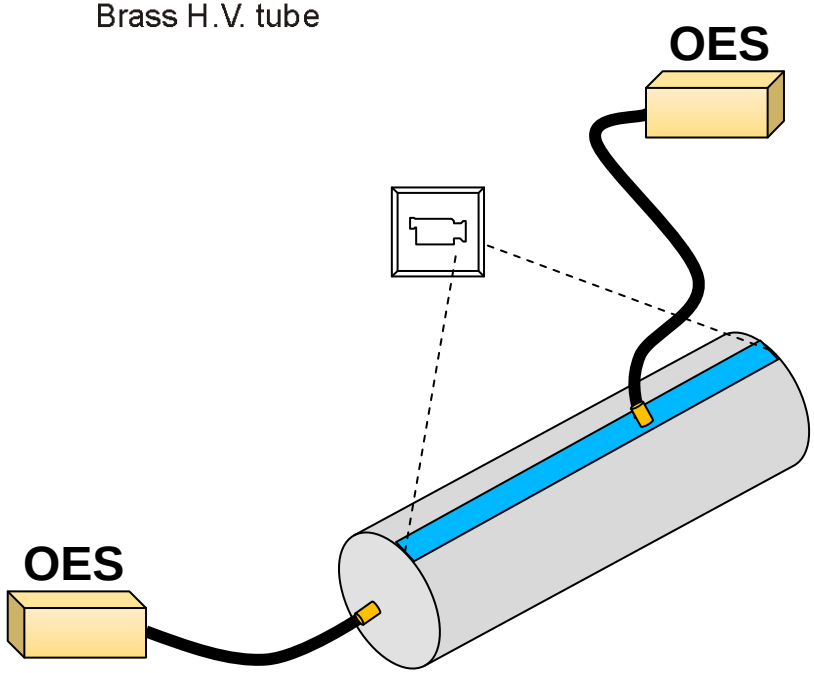
- The growing interest in using biofuels
- Catalyst deactivation by H_2S traces in biomethane
- A few papers only on H_2 production from real biomethane using plasma methods

Biomethane – composition

Components	Household waste	Wastewater treatment plants sludge	Agricultural wastes	Waste of agrifood industry
CH4 % vol	50-60	60-75	60-75	68
CO2 % vol	38-34	33-19	33-19	26
N2 % vol	5-0	1-0	1-0	-
O2 % vol	1-0	< 0,5	< 0,5	-
H2O % vol	6 (à 40 ° C)	6 (à 40 ° C)	6 (à 40 ° C)	6 (à 40 ° C)
Total % vol	100	100	100	100
H2S mg/m3	100 - 900	1000 - 4000	3000 – 10 000	400
NH3 mg/m3	-	-	50 - 100	-
Aromatic mg/m3	0 - 200	-	-	-
Organochlorinated or organofluorated mg/m3	100-800	-	-	

DBD reactor



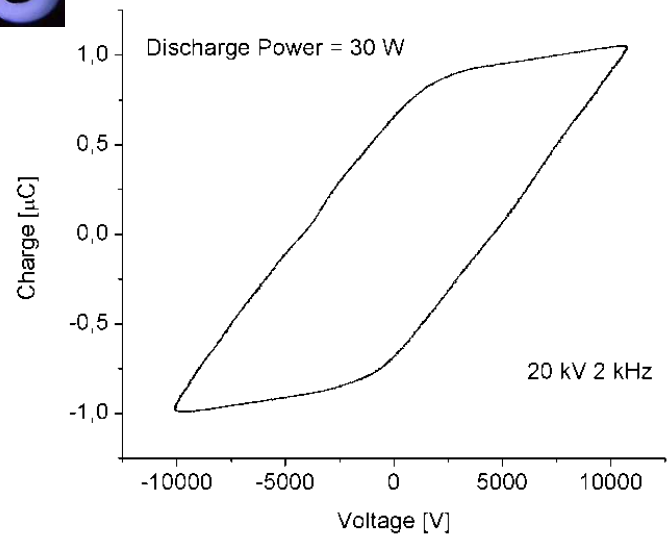


- **Quartz glass tube: inner diameter 15 mm**
- **RVC (Reticulated Vitreous Carbon) electrode:**
  - **outer diameter 8 mm,**
  - **inner diameter 3 mm,**
  - **length 150 mm;**
  - **low porosity 80 ppi (pores per inch),**
- **Gas composition and flow rate:**
  - **CH_4:CO_2 = 70%:30%**
  - **200 cm^3/min.**

Power supply

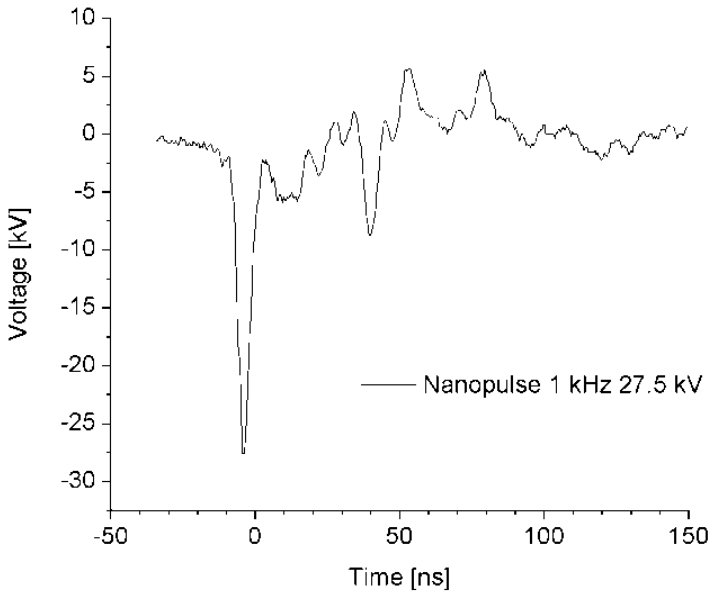
AC sinusoid voltage

- Function generator Tektronix AFG3101,
- Amplifier TREK 40/15,
- Frequency up to 2 kHz
- In this work up to 35 kV_{p-p}

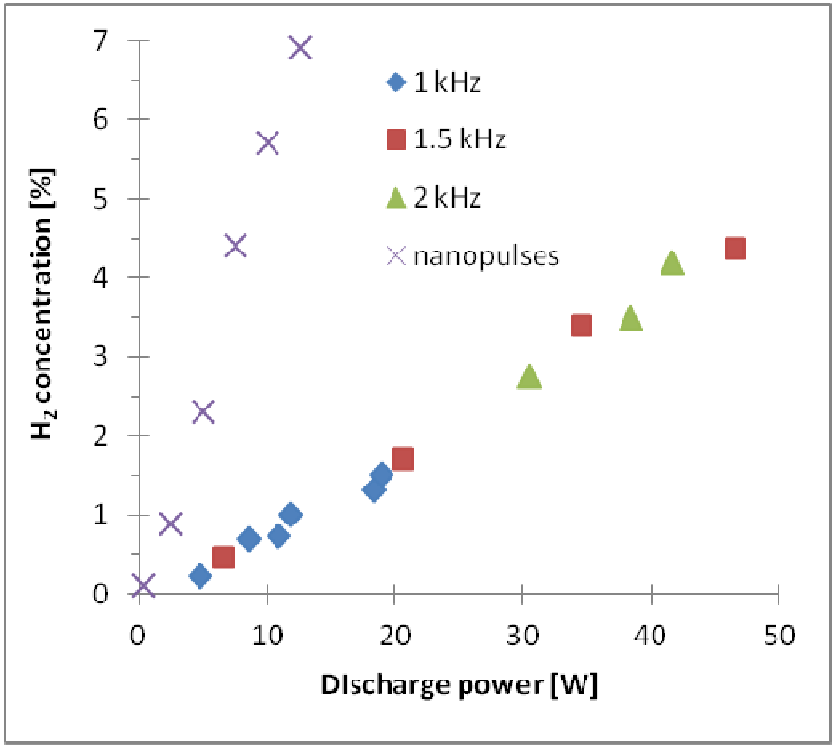


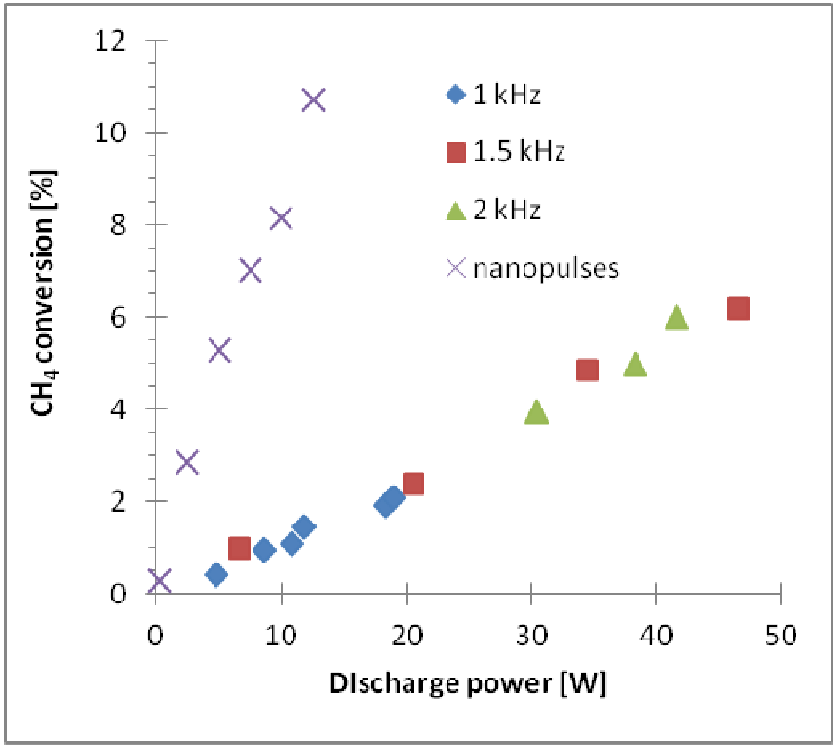
Nanosecond pulses

- Pulse generator NPG-15/2000 by Megaimpulse Ltd.,
- In this work: -29 kV, 50 Hz – 2.5 kHz



Results – gas composition

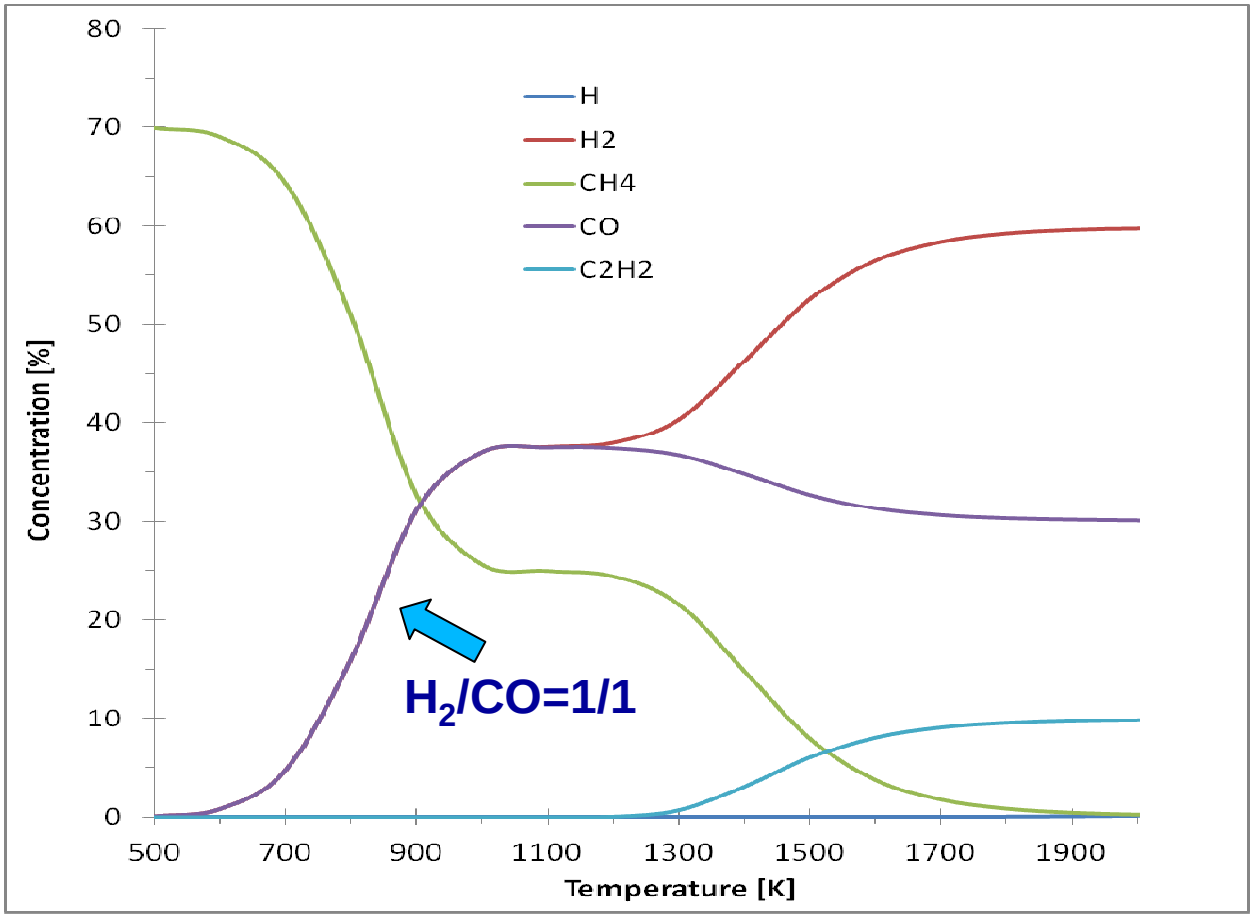




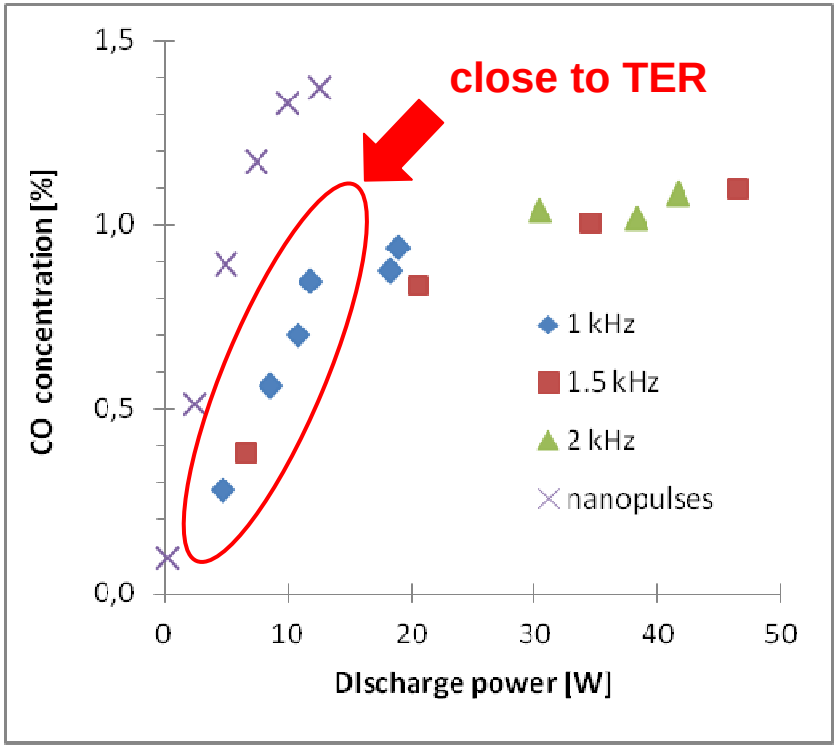
$CH_4 + CO_2 = 2\,CO + 2\,H_2$???

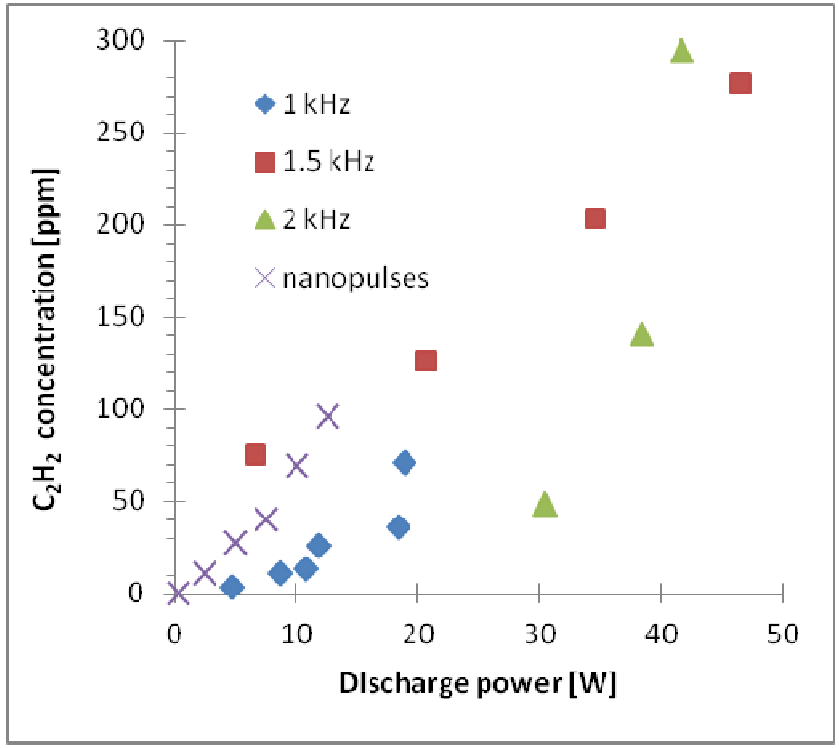
Results – modelling in TER

$$CH_4 + CO_2 = 2\,CO + 2\,H_2$$

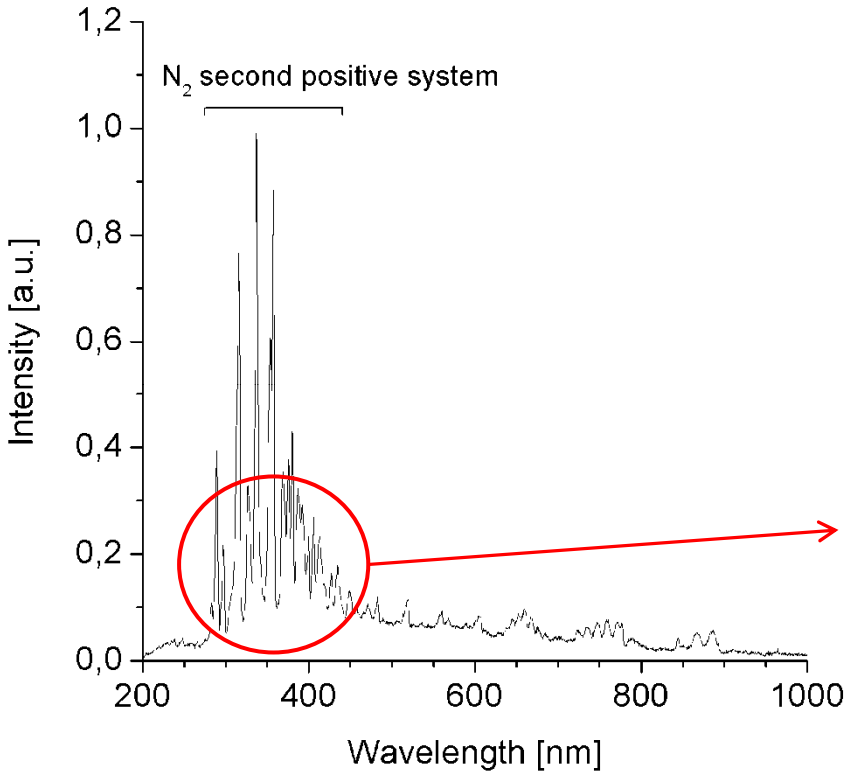


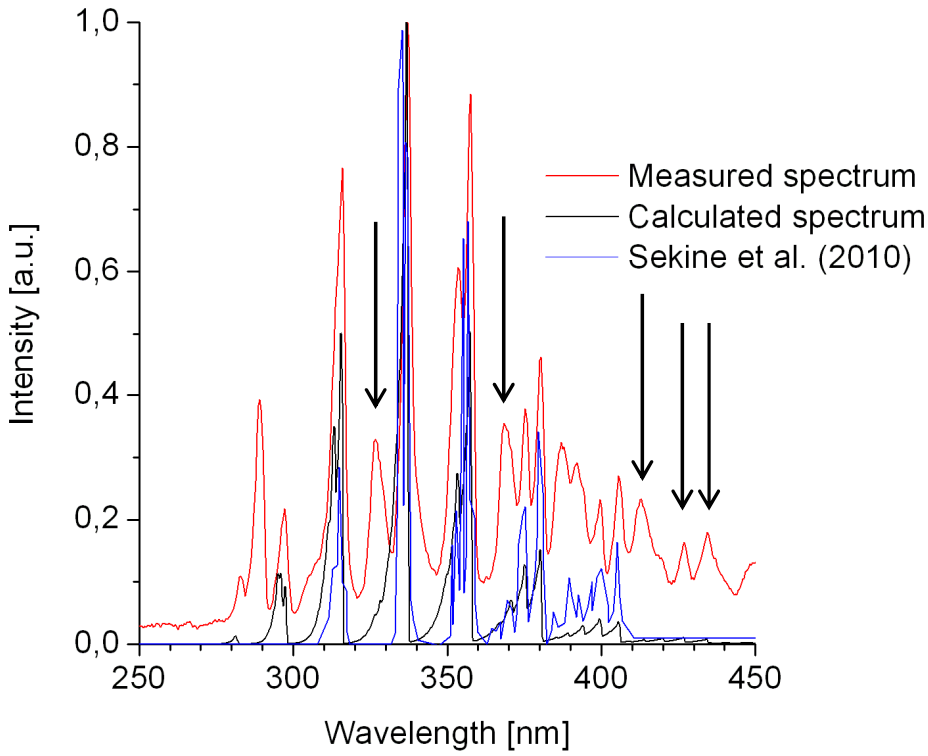
Results – gas composition (cont.)





Results – optical emission spectroscopy

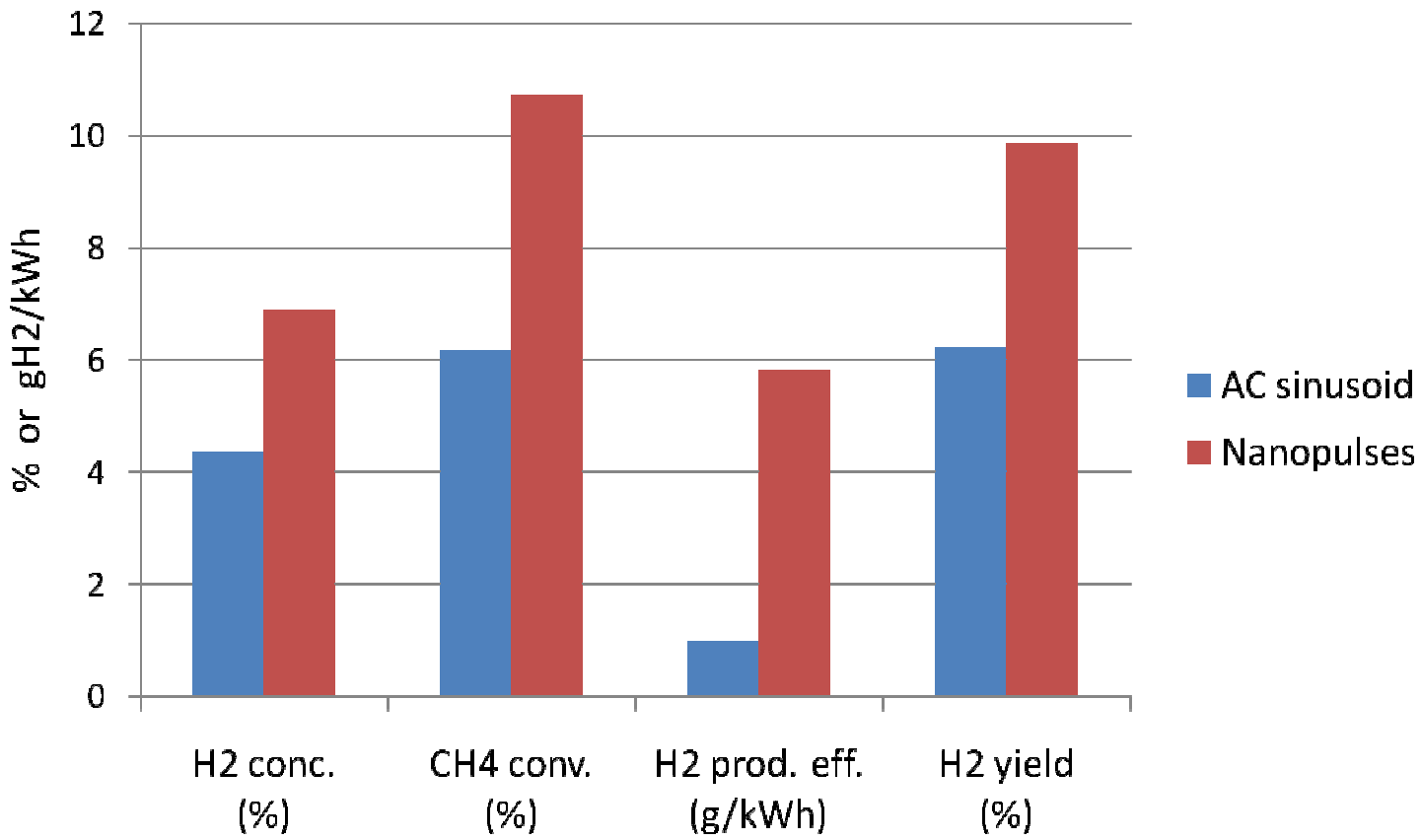




no C_2 Swan system, no CN system

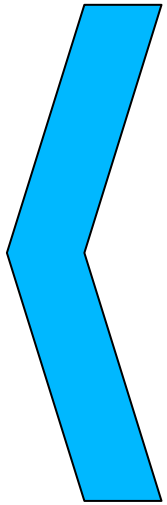
no soot deposition, no changes along the reactor

Results – summary



Tasks in progress

- H_2O admixture
- H_2S admixture
- Higher temperature (up to 250^oC)
- Ni-catalyst



GC

FTIR

2D OES-ICCD

Summary and conclusions

- Hydrogen production and methane conversion degree increase linearly with discharge power in the range of up to 50 W
- Nanosecond voltage pulses are much more efficient in hydrogen production than AC sinusoid voltage
- Conversion of methane in DBD exhibits different chemistry than that typical for thermodynamic equilibrium. Where is the rest of C?