Mitis

Products and services …

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MITIS: vision and values

About us …

- Belgian start-up created in 2012
- Located in Liège (University Campus)
- Shareholders: private investors and semi-public local investment fund
- Main partners:
  - University of Liège (thermodynamics lab)
  - University of Brussels (aero-thermo lab)
  - Karlsruhe Institute of Technology (KIT)
  - Belgian Research Centers (Cewac, Sirris)
  - ANSYS inc

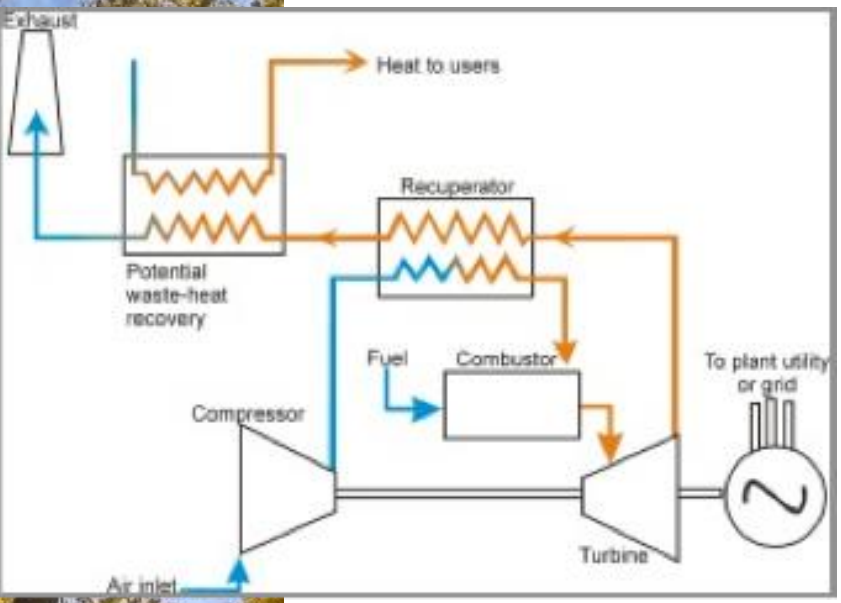
Vision

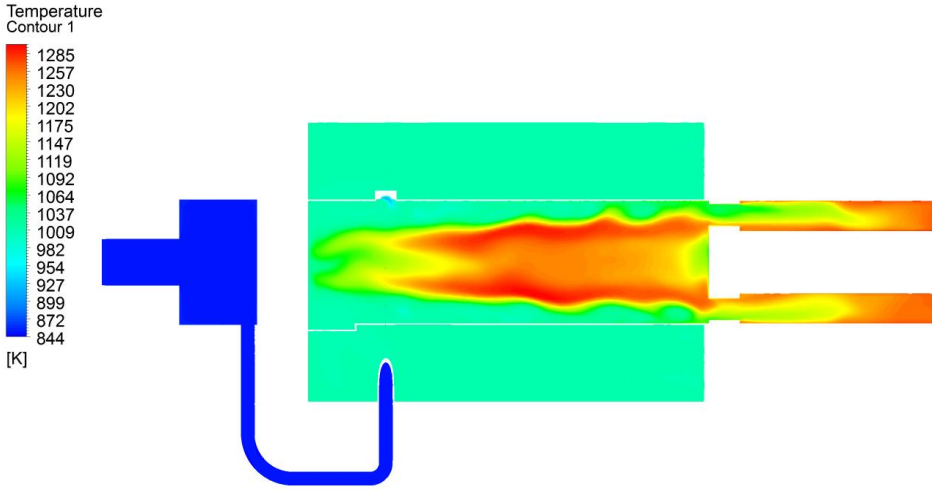
- Contributing to a cleaner world through decentralized power generation
- Develop & Deploy high-efficiency microCHP systems for residential households based on a recuperated very small gas turbine
- **Technology target:**
  - Efficiency : > 30%
  - Flameless combustion : no NOx
  - Oil free, low maintenance
  - Attractive price ~ Stirling engine, largely lower than Fuel Cells

« Key technologies »

- Flameless natural gas combustion chamber
- High efficiency, compact, high temperature heat exchanger (recuperator)

Patent pending 2015/5054, Feb 2015





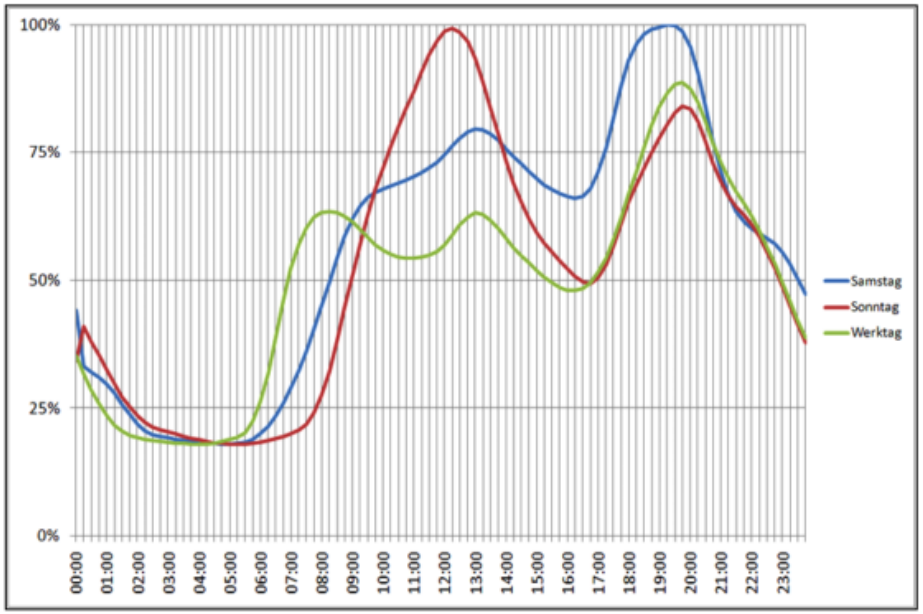
Micro-CHP: Why?

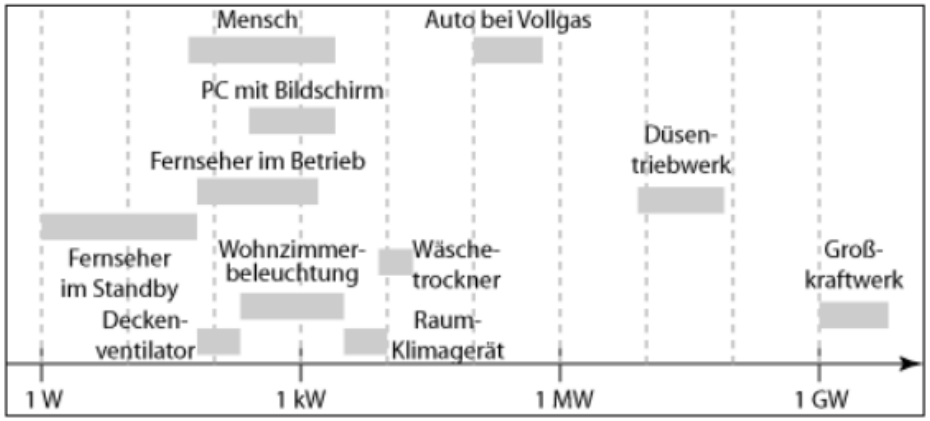
Environment: Micro-CHP ?

- Micro-CHP = combined production of heat and power with power < 50kWe (household (1kWe) => small businesses)
- Households and small businesses = 40% total energy consumption in Europe and 36% CO2 emissions
- > 2050: doubling of electric energy demanding total consumption
- Renewables increasing but insufficient to cover peaks and fluctuations
- Micro-CHP pushed by EU (Energy Efficiency Directive 2012/27/EU), Eco-design, Energy-Labelling directives

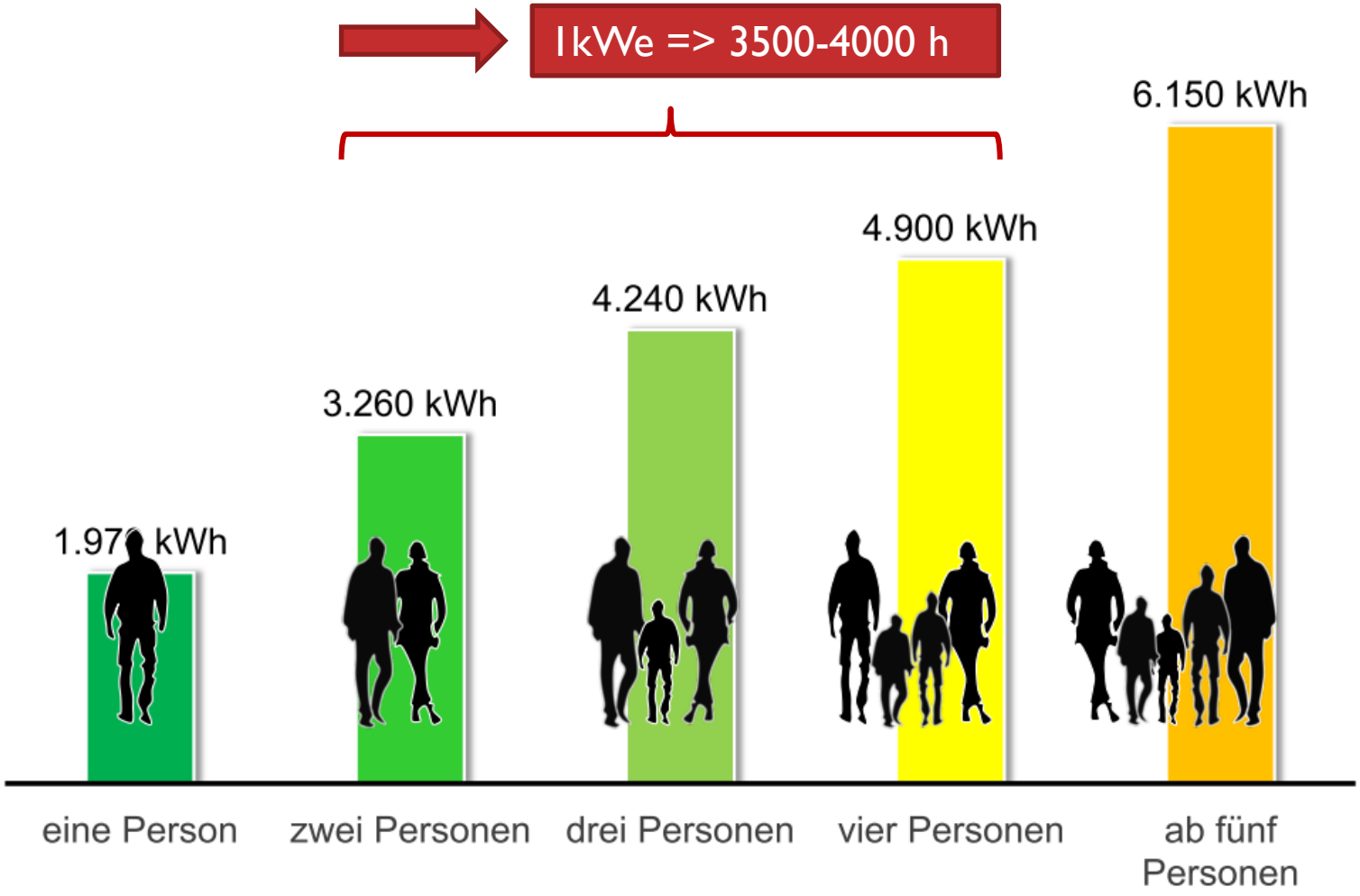
Household micro-CHP : target power

Type	Puissance (W)
Lampe	50
Laptop	80
Frigo	120
Congélateur	150
TV-Flatscreen	150
PC	250
Hotte	500
Micro-ondes	800
Sèche-cheveux	2.000
Bouilloire	2.200
Lave-linge	2.300
Aspirateur	2.400
Sèche-linge	3.000
Lave-vaisselle	3.000
Four à air chaud	4.000





Household micro-CHP : target power



Target household …

- Electric power ~ **1 kWe / family**
- Maximum self-consumption
- Maximum running time > 3500 h/year
- P_{therm} reduced as much as possible:
  - high electrical efficiency
  - Reduced size thermal buffer water tank

Design of small flameless combustors (natural gas)

Conception

Fabrication prototyping

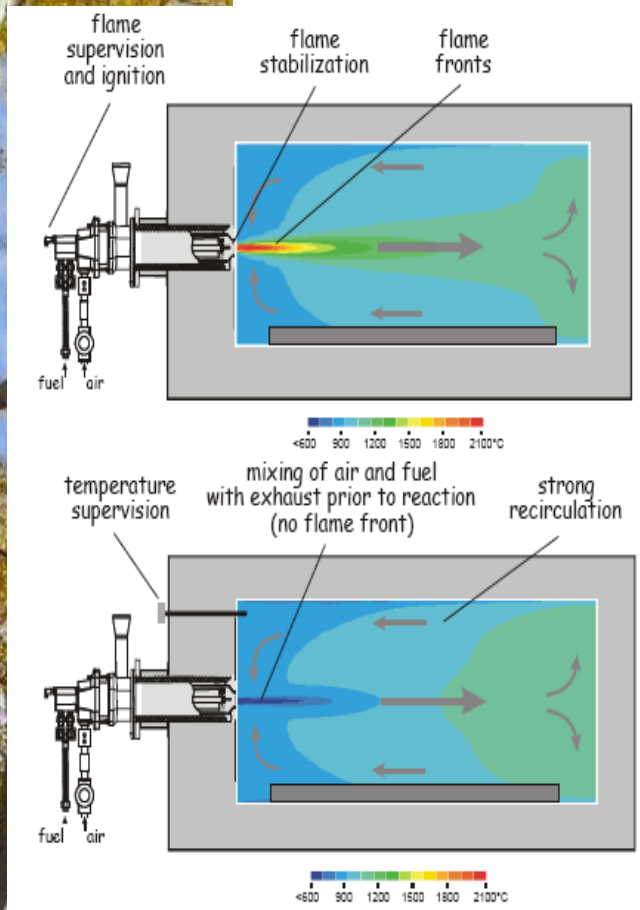
Experiments

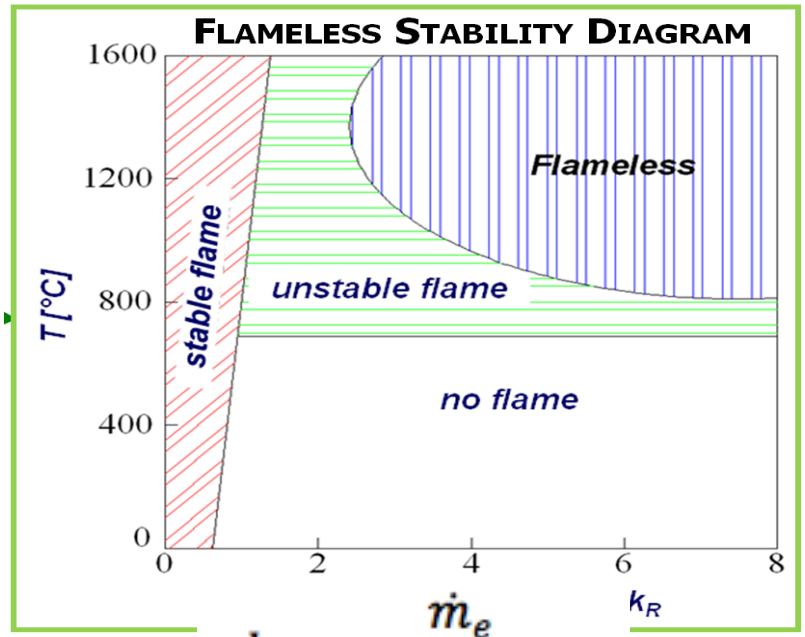
Flameless combustion

- Maintaining the reaction temperature below 1700 K to avoid the production of thermal Nox
- Principle: maximum dilution of fuel in air and bringing mixture to self ignition => Perfect Stirred Reactor
- Intensified turbulence levels have the effect of smoothing, reducing the macroscopic gradients leading to smaller O2 concentrations and to smoother temperature profiles.
- Chemical time scales are increased while turbulence times are decreased leading to a kinetic control of the process.
- Usual methodology: Recirculation of flue gas
- Result: very stable, low NOx

Flameless combustion

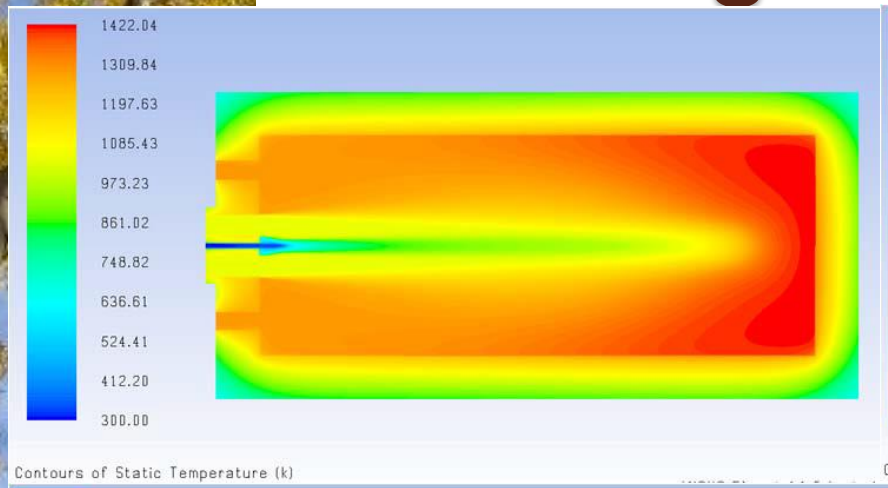
- High combustion efficiencies.
- Low pollutant emissions.
- Large fuel flexibility.
- Stable and noiseless.

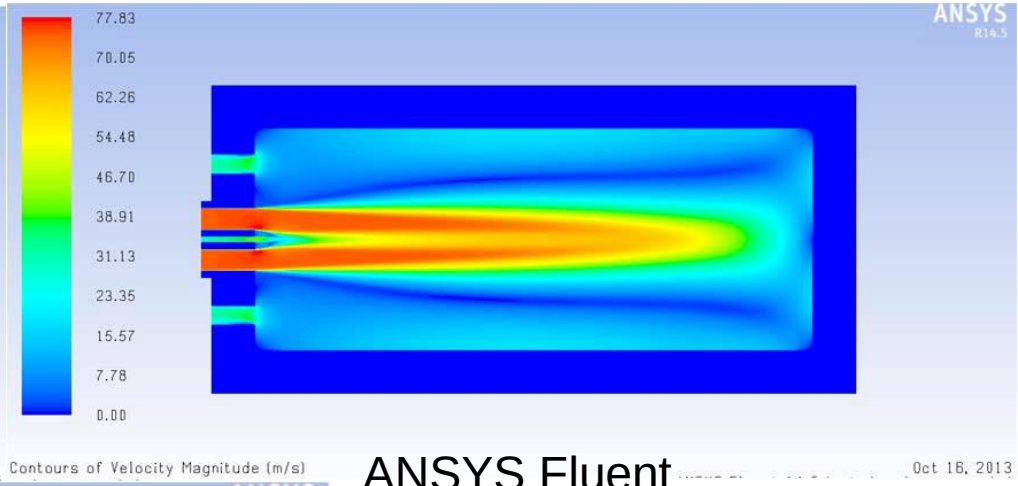


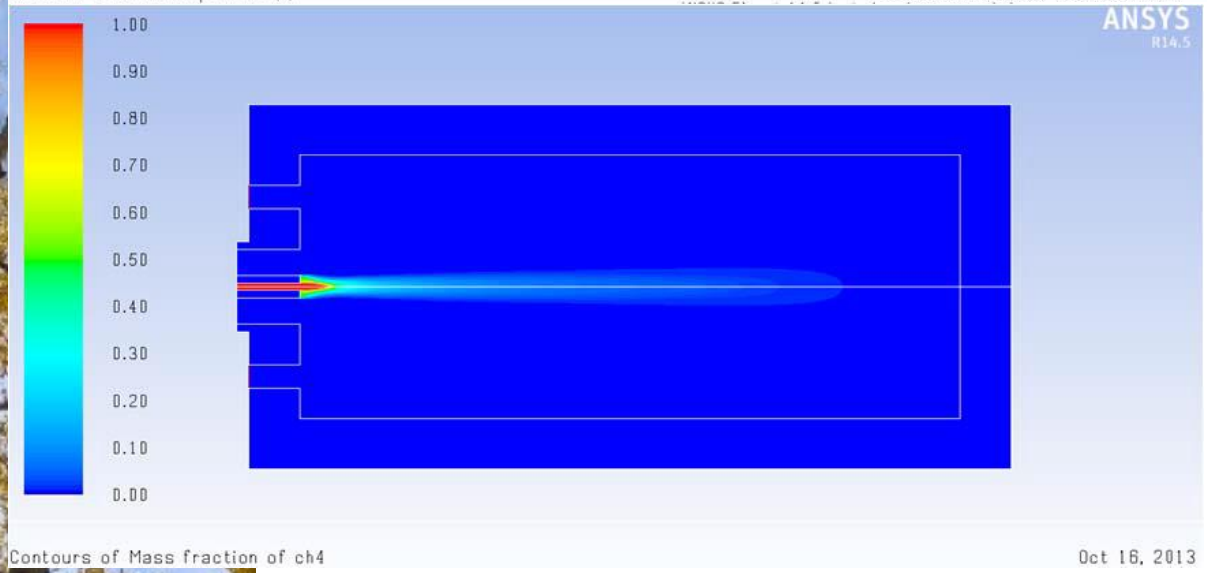


$$k_R = \frac{\dot{m}_e}{\dot{m}_f + \dot{m}_a}$$

First design: Can combustor







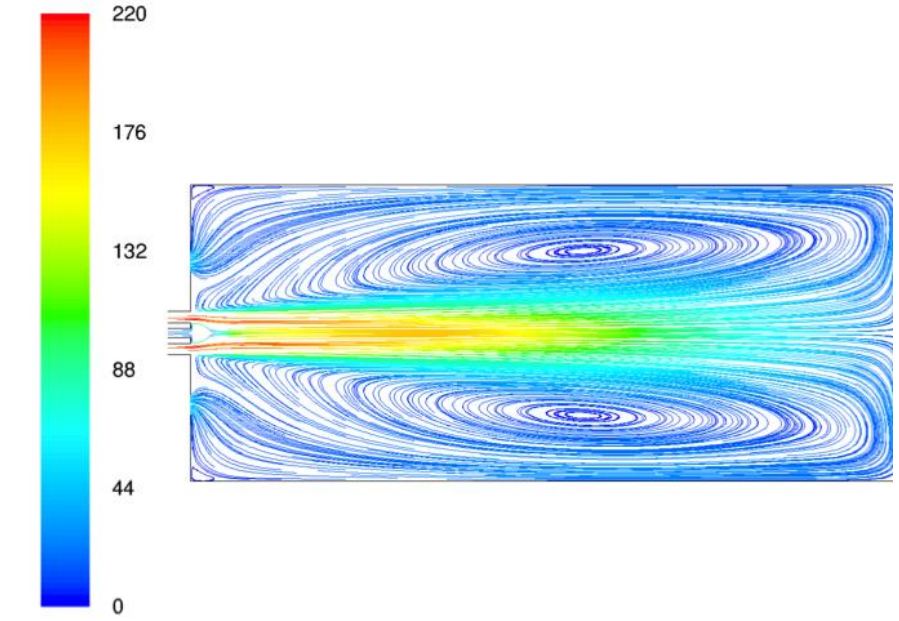
ANSYS Fluent
CHT with radiation

For design: one reaction
O2, CO2, H2O, CH4
Finite rate – Eddy Dissipation

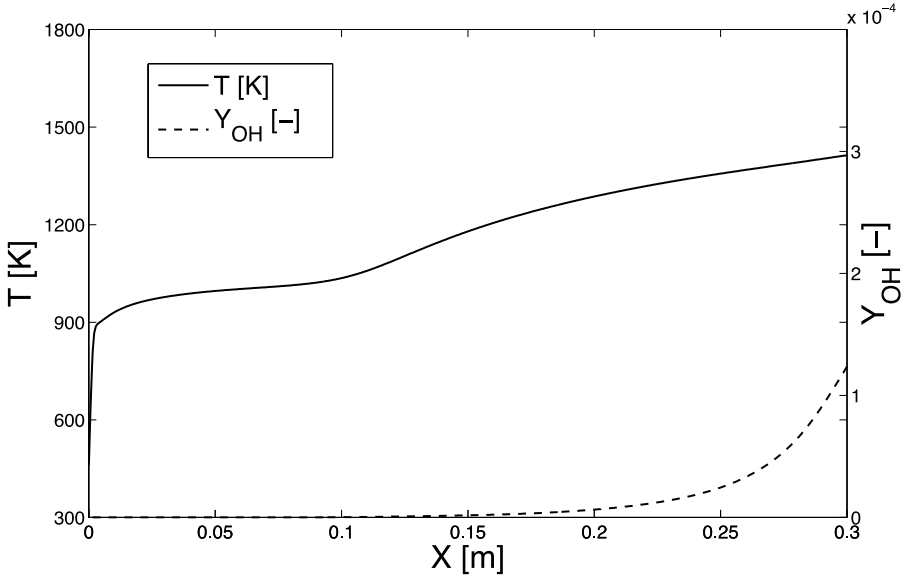
For verification:
Eddy Dissipation Concept
Detailed reaction mechanisms
KEE58, GRI 2.11, GRI 3.0

First design: Can combustor

- The exhaust gases outlet is placed on the same side of the inlets to avoid the flame blow out.
- k_R = 1.42.



Velocity [m/s] distribution



Temperature [K] and OH mass fraction [-] along the chamber axis.

The same methodology was applied to design a vortex flow based burner achieving flameless combustion and adapted to a 3kWe micro CHP system

The design is patent pending N°2015/5054 at the Belgian office of Intellectual Property

Design of micro heat exchangers

Conception

Fabrication prototyping

Experiments

Microchannels heat exchangers

- In collaboration with KIT
- Design a microchannel gas heat exchanger with diffusion bonding
- Design, analysis and optimization

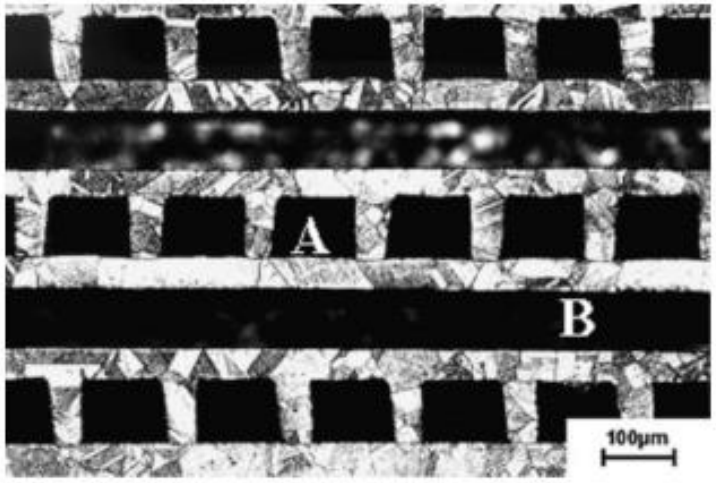
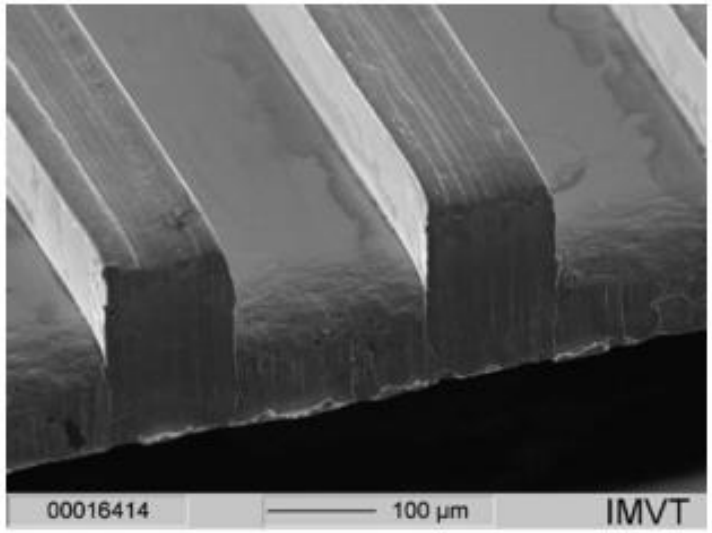
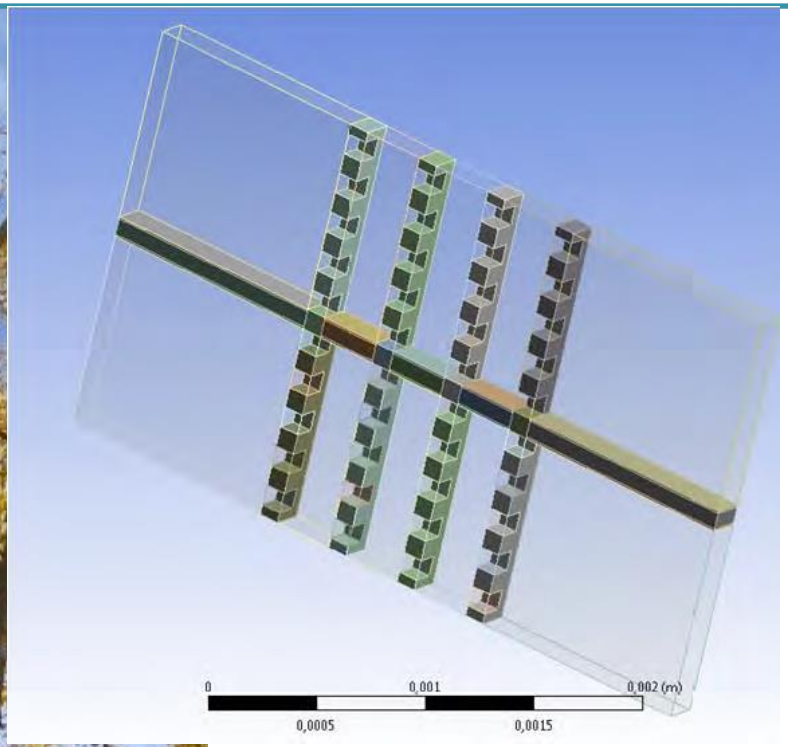


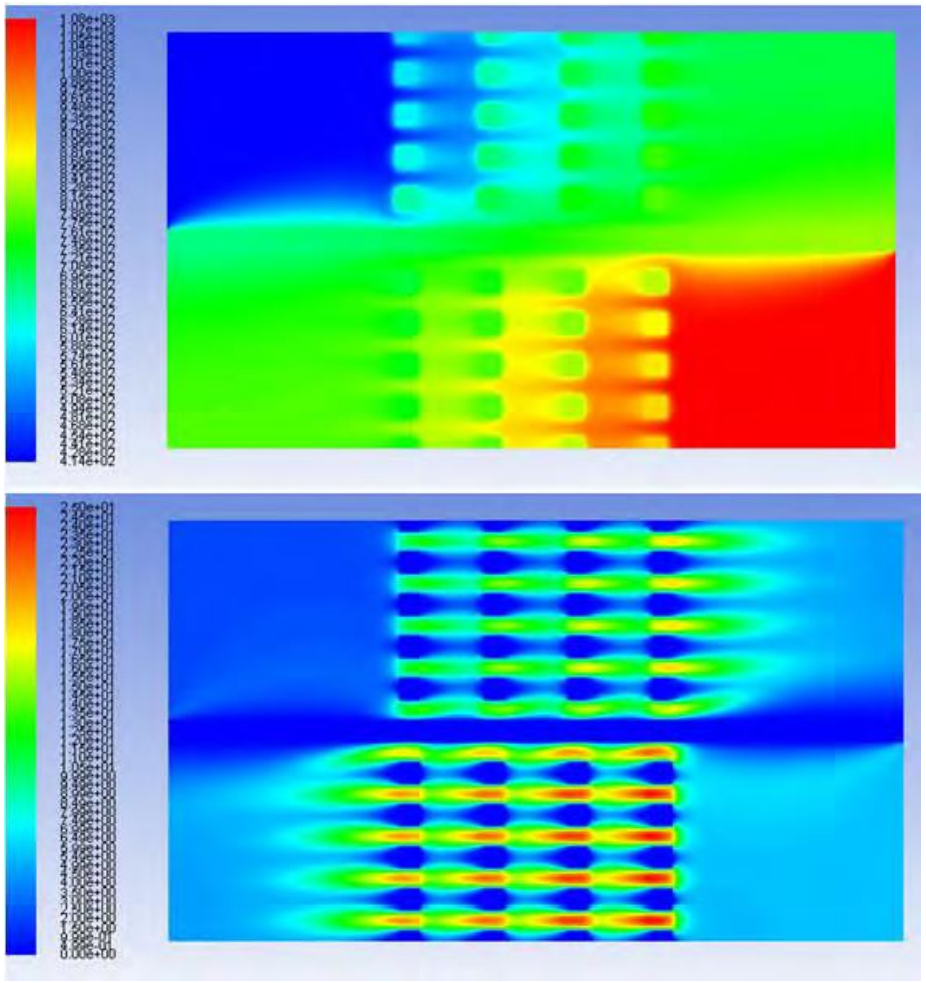
Fig. 2. Optical micrograph of a plane cut through a stainless steel



Micro HEX: Optimization

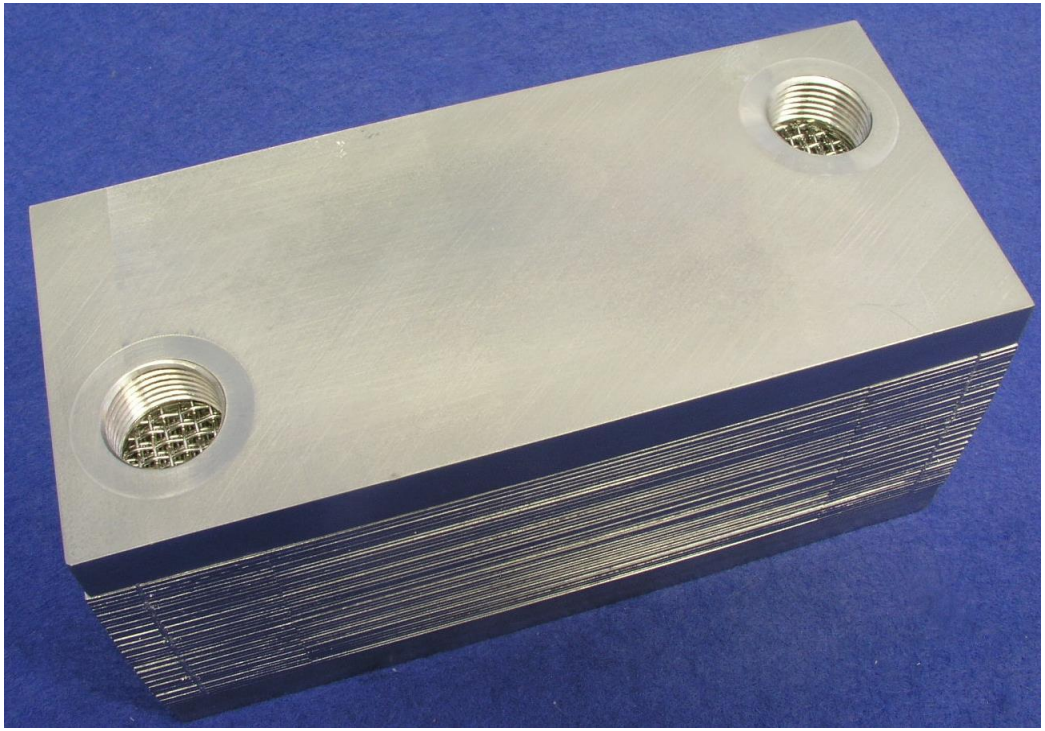
- 3D CHT geometry optimization





Micro HEX: Manufacturing

- Diffusion bonding & Laser Welding



Our challenges …

- Trust and confidence in modelling the flameless combustion regime => affordable (design), yet accurate (extinction issue, temperature) predictions
- Affordable manufacturing method for complex microstructure small heat exchanger => additive manufacturing
- Designing .5 MRPM turbomachinery parts
- High temperature resisting materials for high speed rotating devices
- Air bearings …
- And many others yet unknown to us …