
Microholes feasibility with regard to diesel and gasoline direct-injection needs

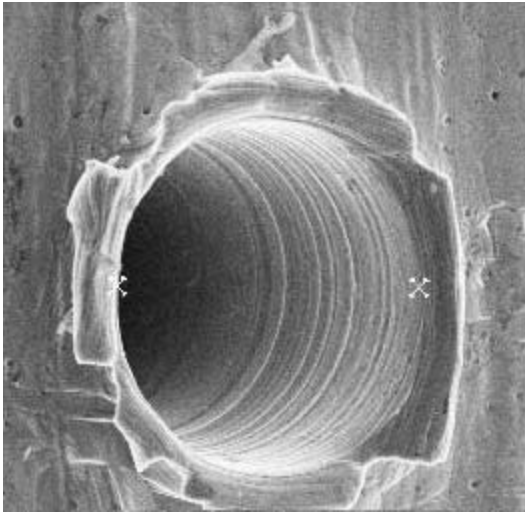


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Summary

- Of holes and men...
- Diesel high pressure needs :
 - From Euro 3 to Euro 5
 - Impact on the hole diameters and shape
 - What next ?
- Hole characteristics for gasoline direct injection
- Drilling technologies :
 - Electro discharge machining : EDM
 - Hybrid EDM
 - Laser
- Posalux SA

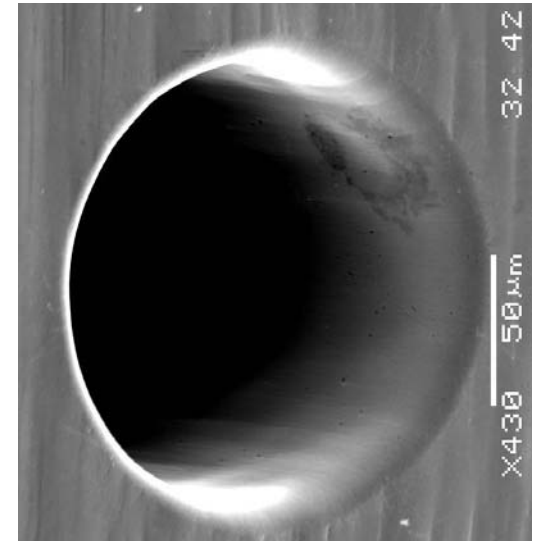
Of holes and men...



Before the diesel high pressure injection revolution, the function of a nozzle hole was only to define a flow without especial characteristics.

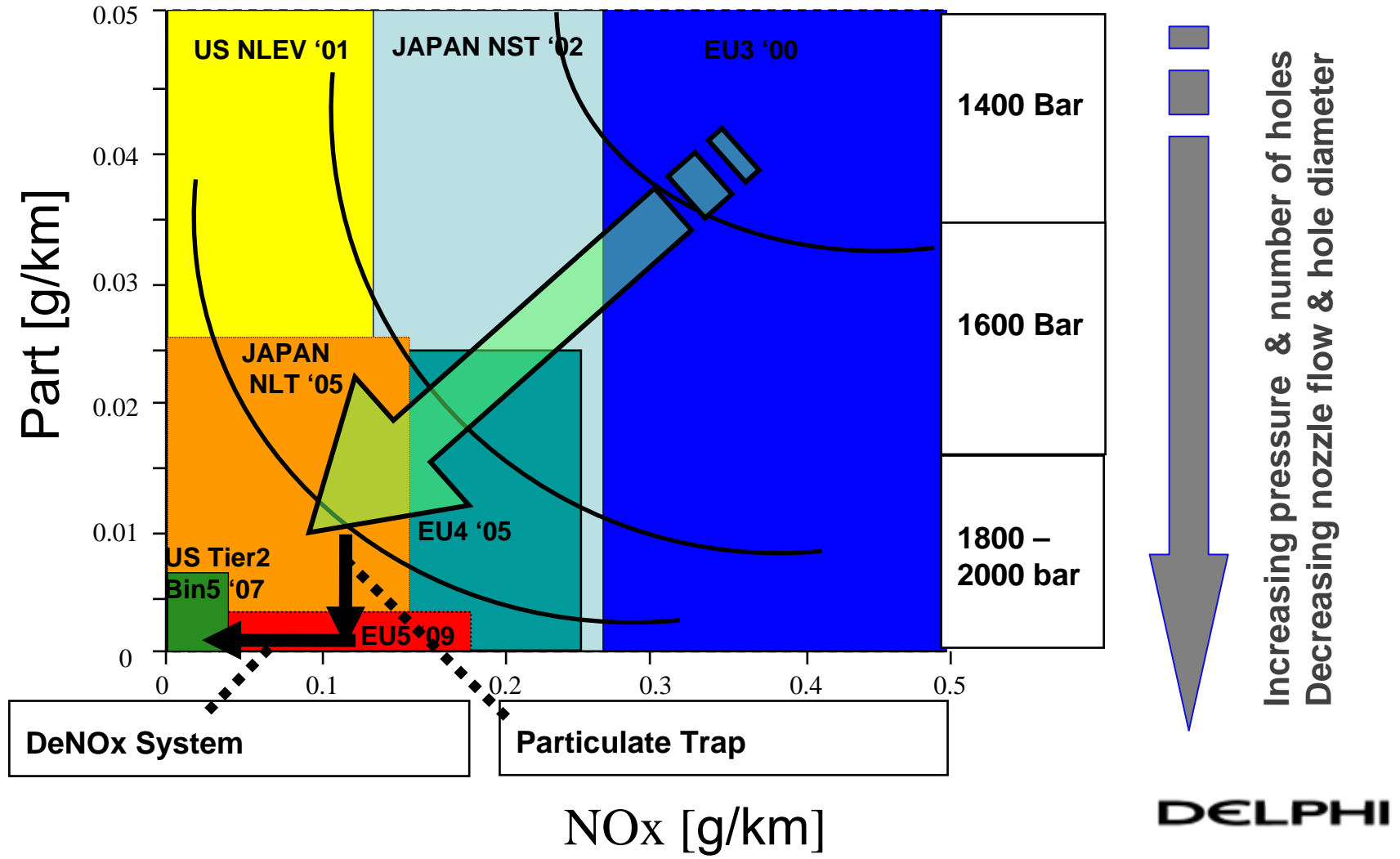
Injection hole mechanically drilled

Today, the hole is considering as “the aim” of the injection and determine not only a flow but also the efficiency of the entire system, through its diameter and shape.

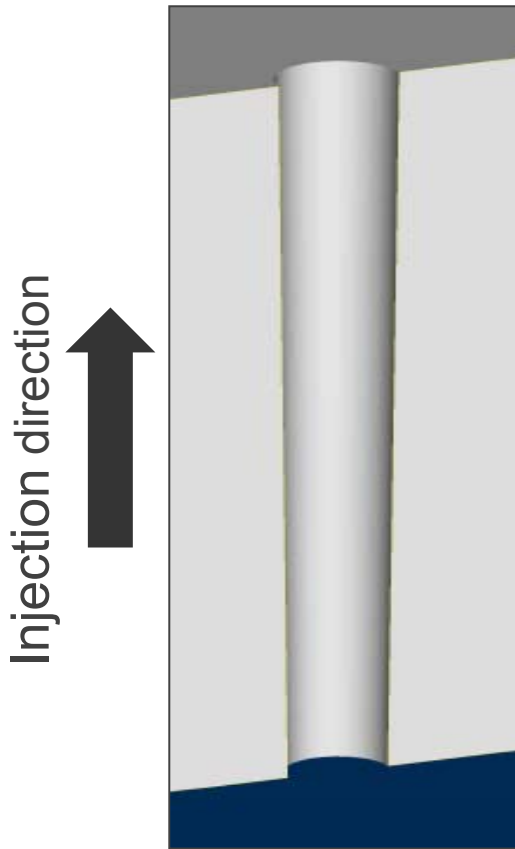


Microhole after radiusing

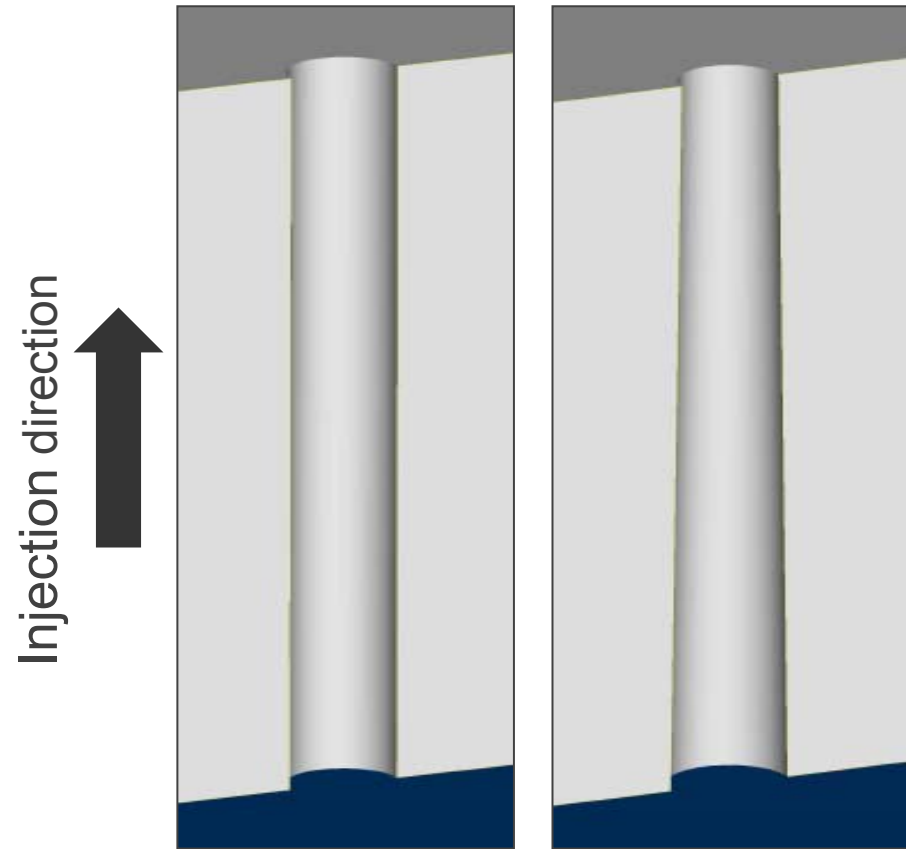
Diesel high pressure needs : from Euro 3 to Euro 5



Diesel needs : impact on the hole diameter and shape

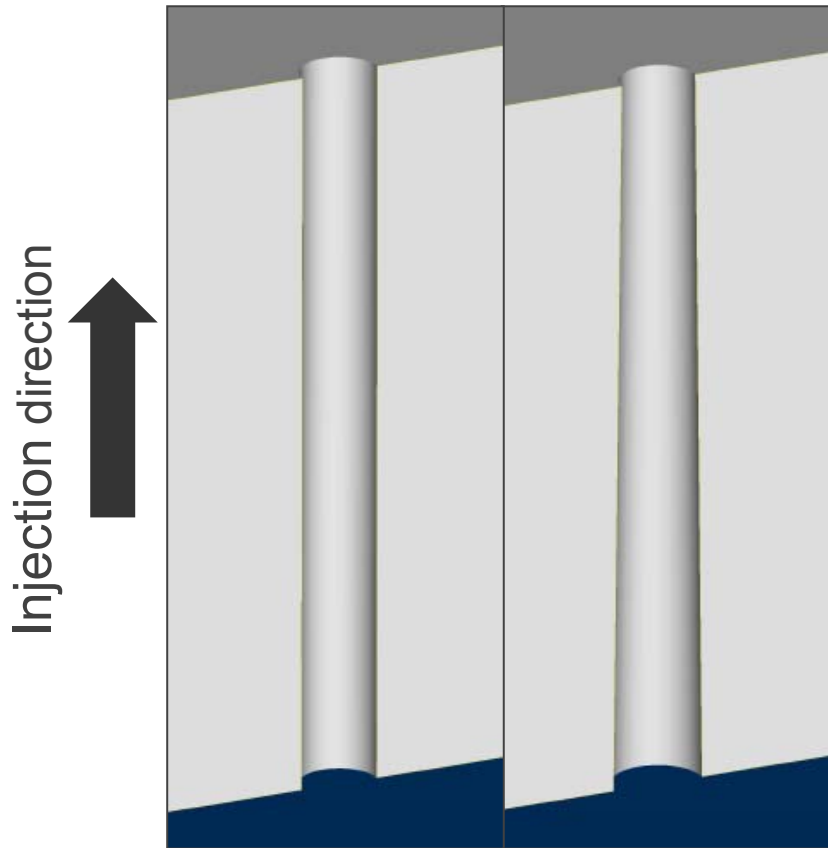


Euro 3 : divergent hole
Average \varnothing : 160 μm



Euro 4 : cylindrical & convergent
hole Average \varnothing : 130 μm

Diesel needs : impact on the hole diameter and shape

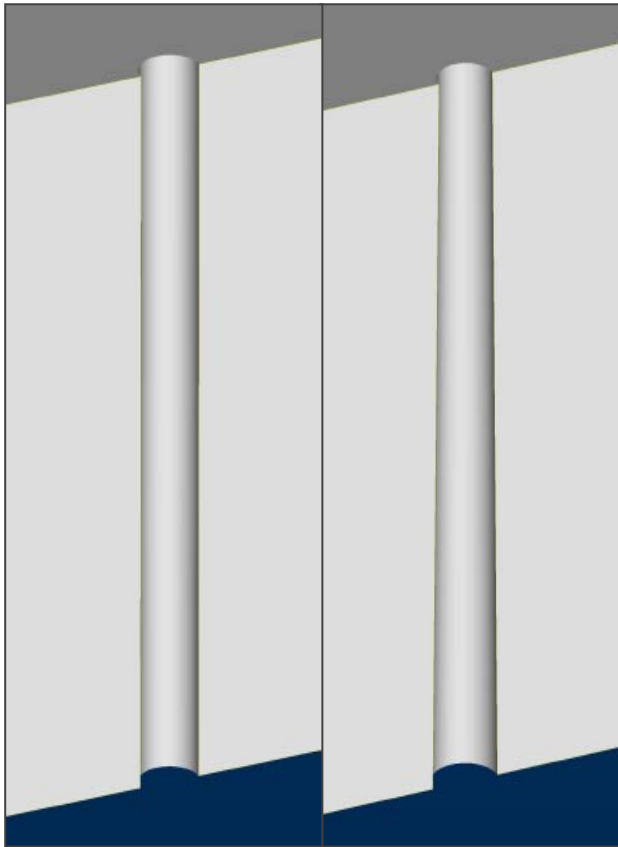


Euro 5 : cylindrical & convergent hole
Average \varnothing : 110 μm

From Euro 3 to 5 :

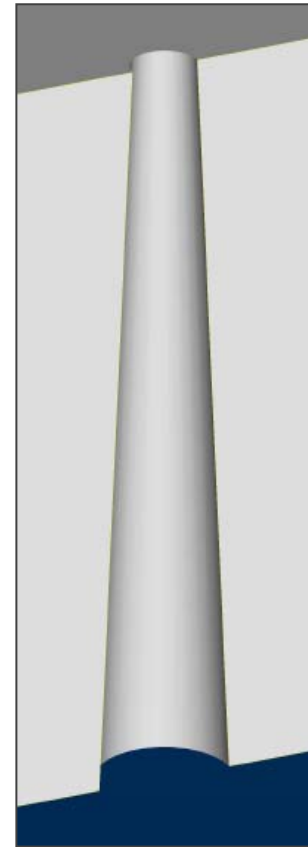
- Increasing the pressure from 1400 to 2000 bar
- Decreasing of the diameter from 160 to 110 μm
- Increasing the number of hole from 5 to 7
- Changing the hole shape from divergent to convergent

Diesel needs : what next ?

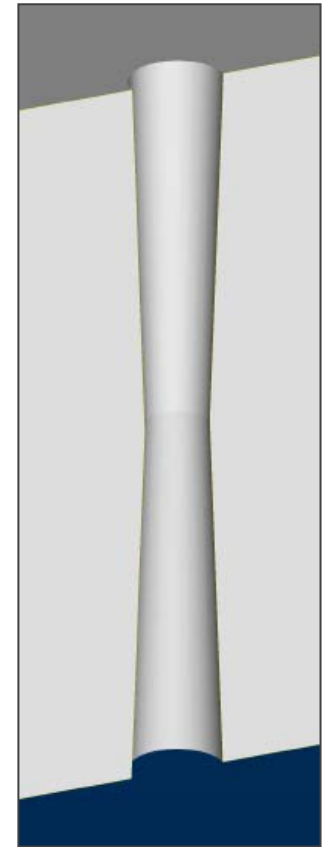


Cylindrical & convergent hole
Average \varnothing : 80 μm

Injection direction
↑

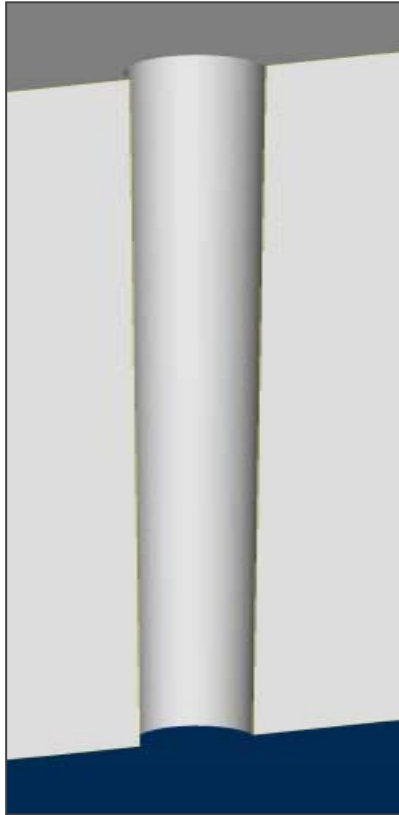


Very convergent hole

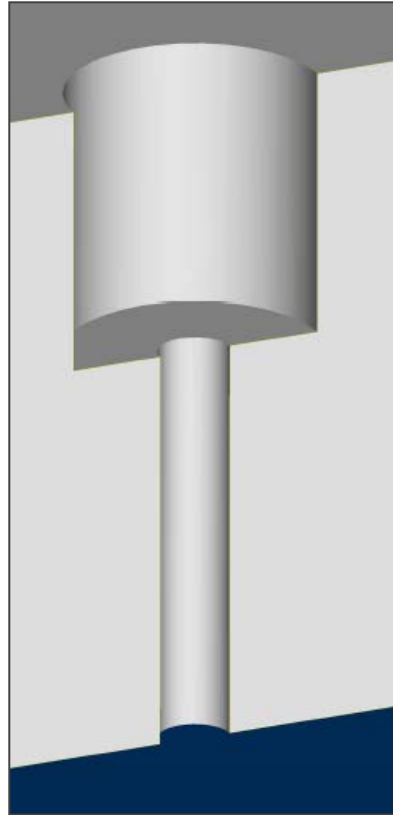


Convergent & divergent hole

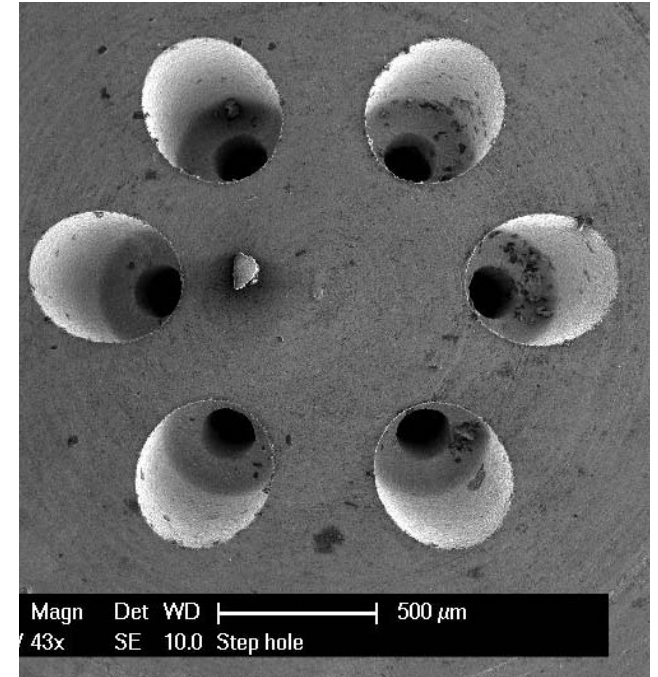
Hole characteristics for gasoline direct injection



1 hole nozzle (swirl)
Average \varnothing : 500 μm

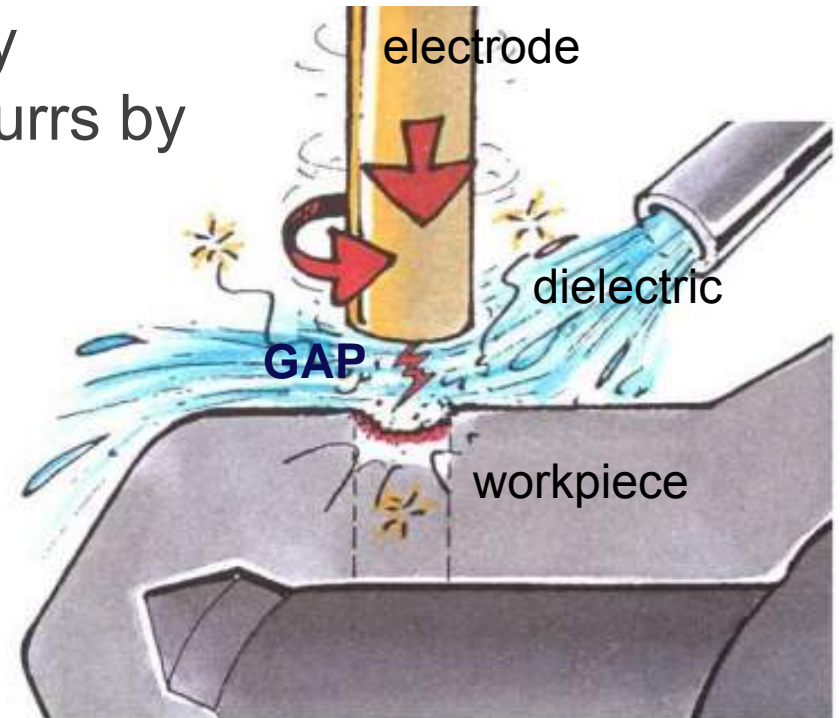
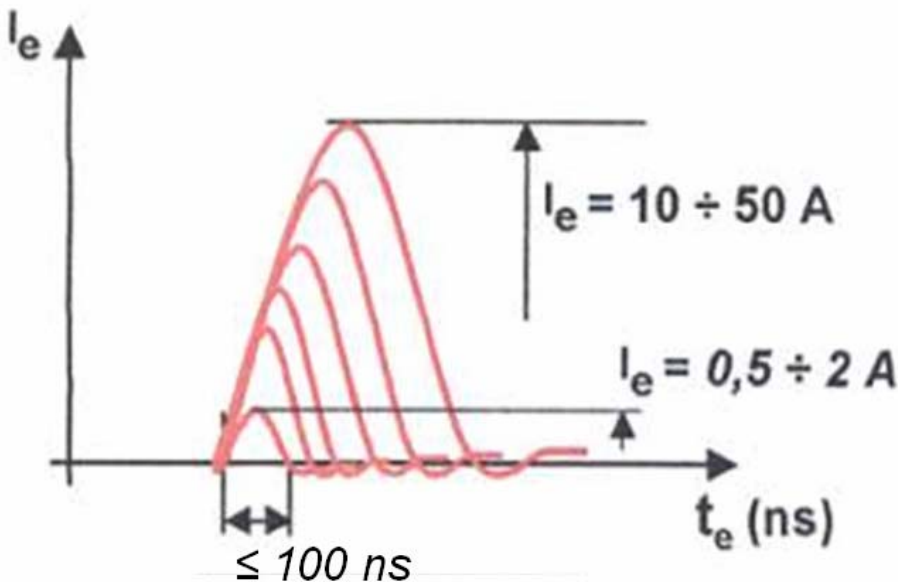


6 step holes nozzle
Average \varnothing : 180 μm



Electro Discharge Machining : EDM

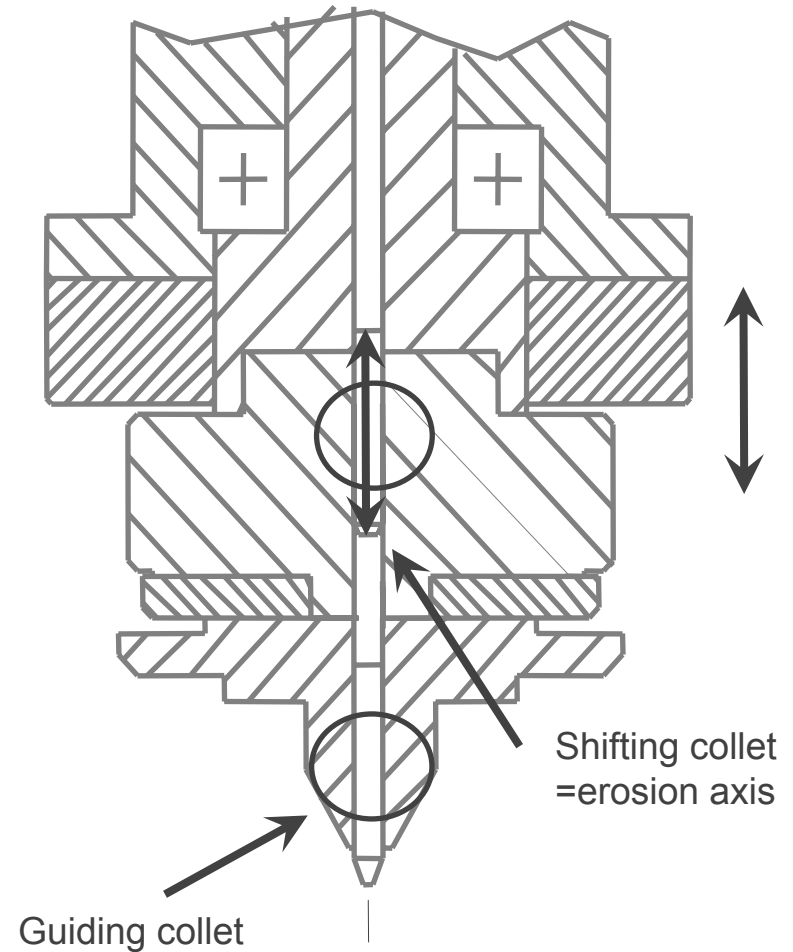
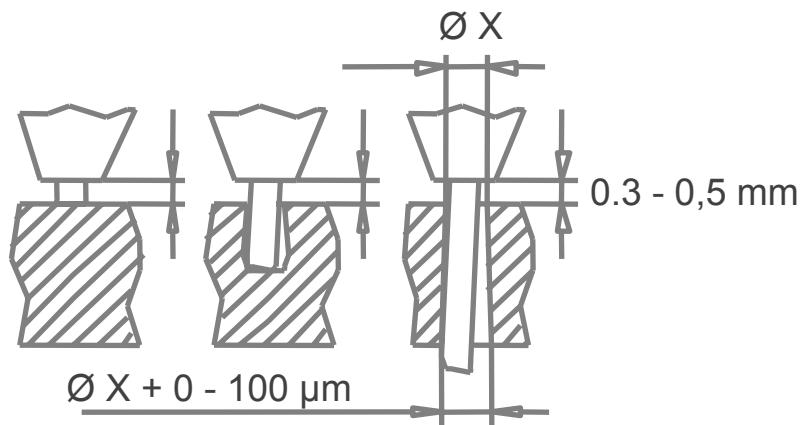
EDM is a process to remove any conductive material without burrs by using electric discharges.



Micro EDM : very short electrical pulses with high energy discharges

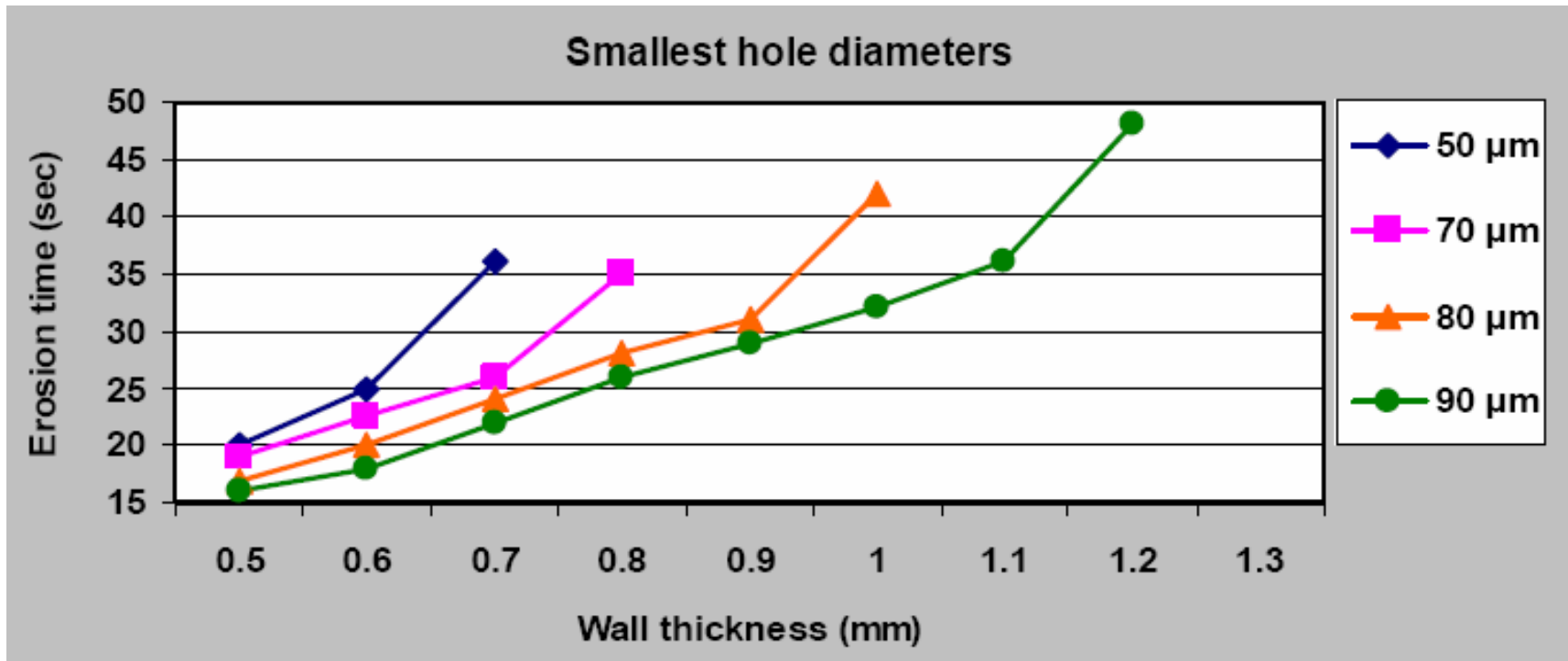
EDM : how to guide so small tools ?

- Hole \varnothing : ≥ 0.050 mm
- Accuracy \varnothing : ± 0.002 mm
- Reverse taper: $0 - 0.100$ mm



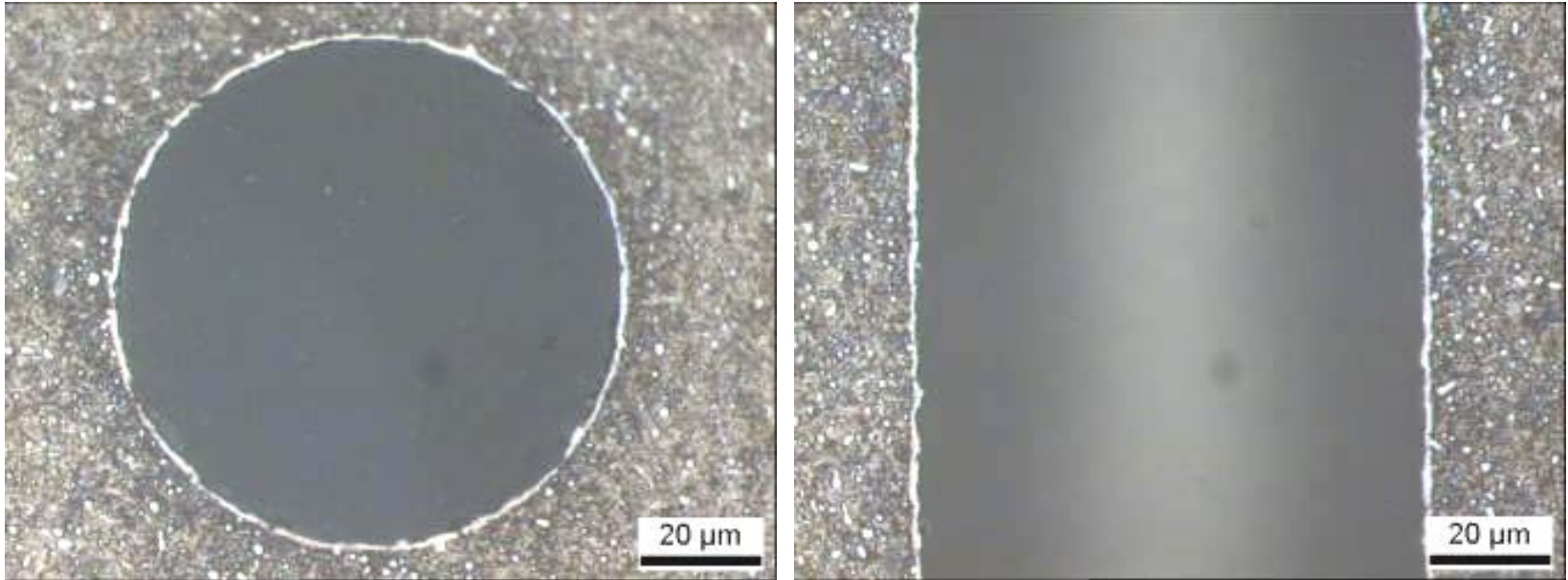
EDM : feasibility limits

- EDM time versus wall thickness



The graph shows the erosion time versus wall thickness for the smallest electrode diameters.

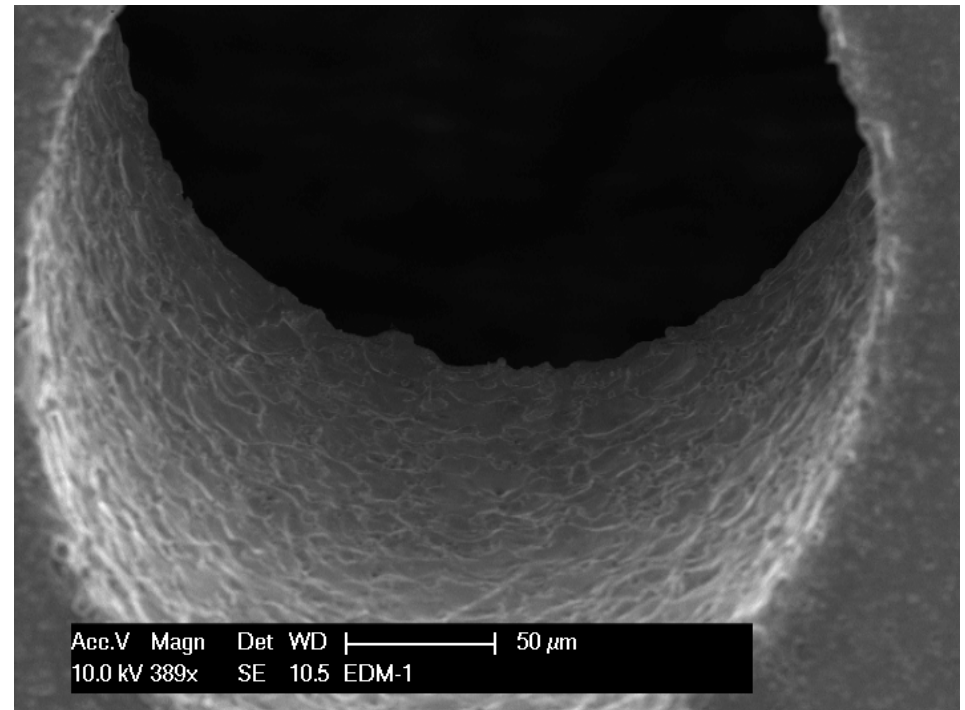
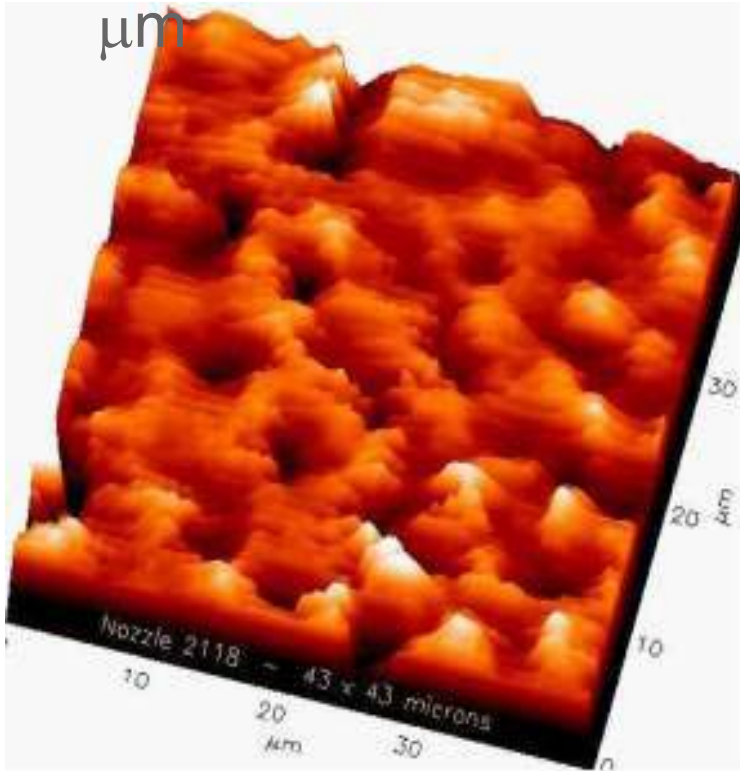
EDM : white layer (heat affected zone)



The hole present a white layer all around the edge with a thickness smaller than 3 μm . No burrs. No deposits.

EDM : roughness

The typical roughness in a diesel nozzle hole is $Ra = 0.5 \mu\text{m}$



With higher energies, the roughness is below $Ra = 1 \mu\text{m}$

Hybrid EDM

Micro EDM with High Dynamic

Vibration of the electrode at ultrasonic frequencies

Development project in collaboration with :

- Ecole Polytechnique Fédérale de Lausanne
- Ecole Nationale Supérieure des Arts et Métiers, Paris
- Sarix SA, Losone

Available : 2nd semester 2010

Hybrid EDM

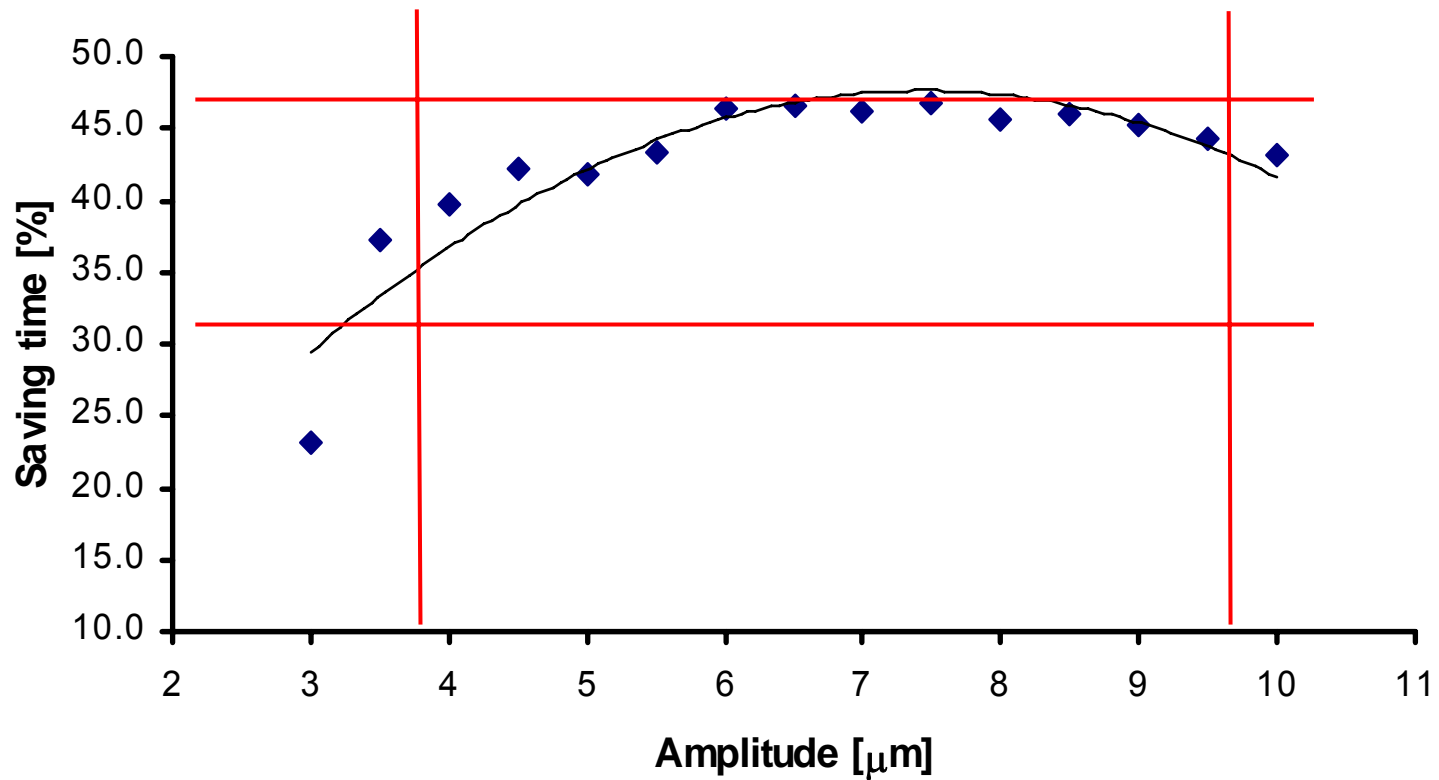
Improve drilling efficiency (quality and productivity)



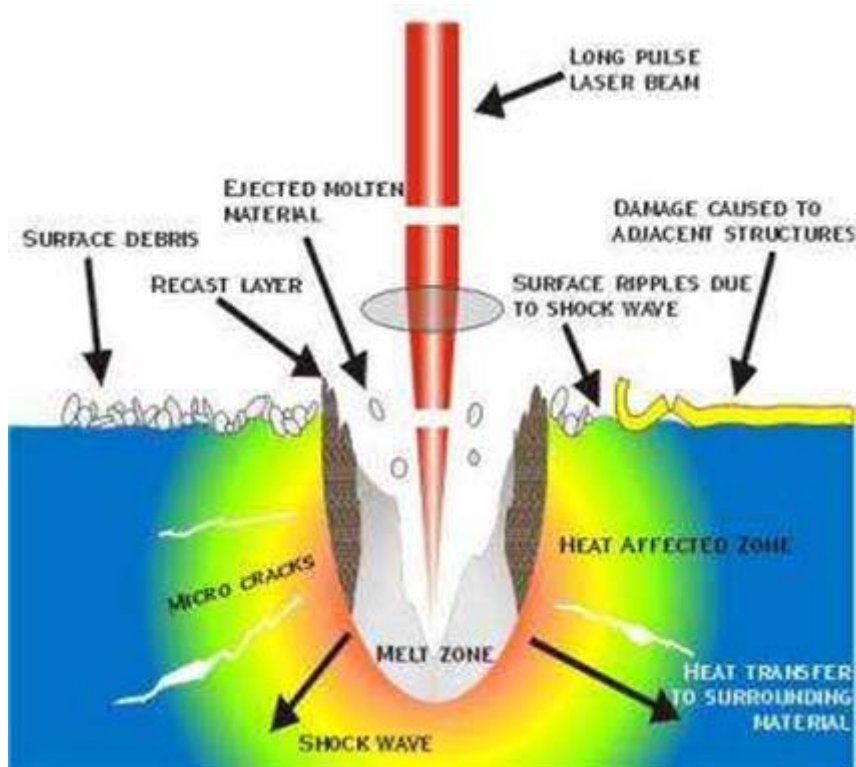
Hybrid EDM

Reference time without vibration : 32 sec. for \varnothing 120 μm , 1mm thickness

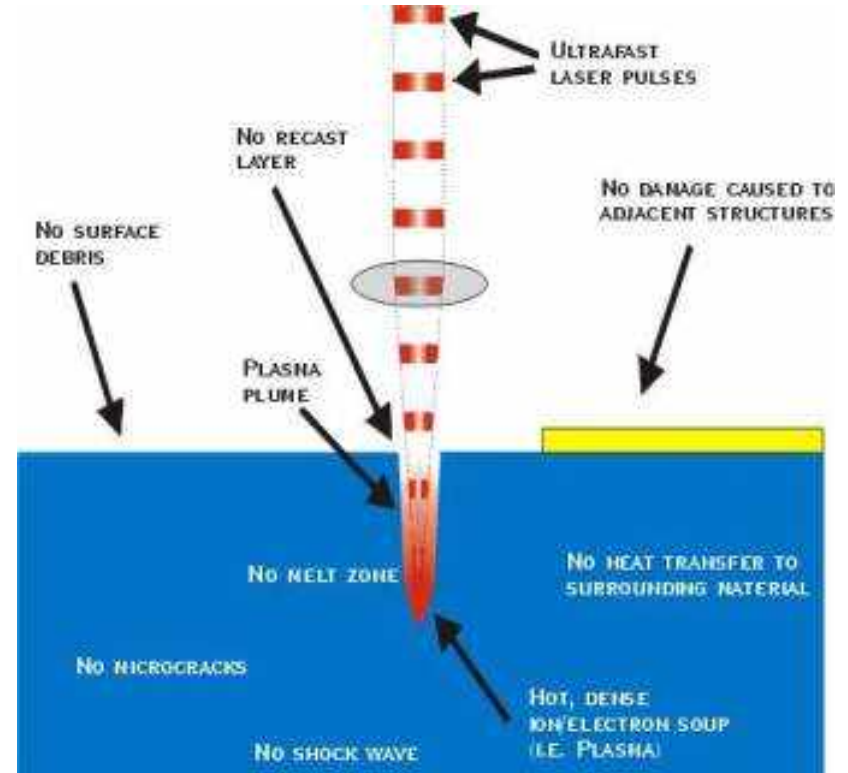
Potential gain



Laser sources from micro to femto second



Micro and nano second laser
Fusion of the matter
Industrial solution

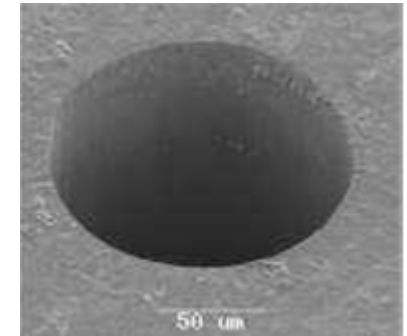
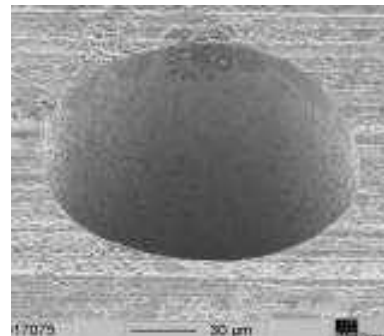
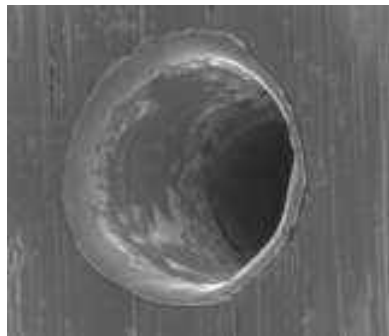
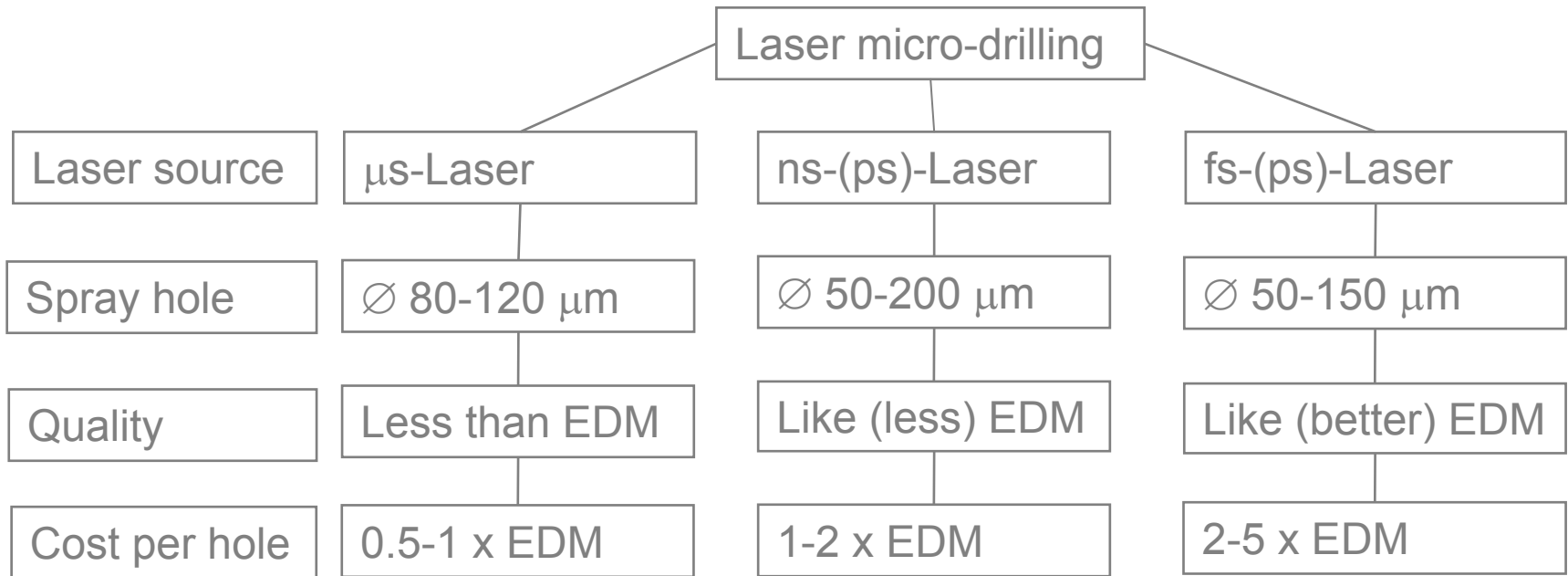


Pico and femto second laser
Vaporization of the matter
Laboratory equipment

Laser : nozzle drilling application

- Industrial solutions : ms and ns laser
 - Laser-matter interaction : fusion
 - Heat affected zone and recast layer : need post process
 - Surface debris : need external protection
 - Back wall impingement : need internal protection
 - Convergent shape : need complex beam management
- Laboratory equipment : ps and fs laser
 - Laser-matter interaction : looking for vaporization
 - Energy per pulse : need to be increased for efficiency
 - Equipment complexity : need clean room conditions

Laser : nozzle drilling application



Posalux SA : products

- Industrial solutions
 - FP1: prototype and quick-turn production
 - HP4: medium to large scale production
 - More than 300 machines delivered worldwide
- Performances:
 - Electrode \varnothing : ≥ 0.035 mm
 - Hole \varnothing : ≥ 0.050 mm
 - Accuracy \varnothing : ± 0.002 mm



Posalux SA : internal quality control

- 140 bar (2000 psi) flow check system
 - Non destructive control
 - Repeatability per head
 - Stability on four heads
 - Hole shape measurement
- Optical measurement machine
 - Hole diameter, shape and position
 - Down to 80 microns hole
 - Reverse taper up to 30 microns
- Roughness measurement system
 - Down to 100 μm hole
 - Destructive control



Posalux SA : key figures

- Privately owned company specialized in mechanical engineering, commercializing machines for mass production
- Focusing on niche markets needing high-tech equipments.
- Headquarter with development and manufacturing based in Switzerland
- Worldwide sales and after-sales organization

- Figures :

- 150 employees in CH
- Turnover 2008 CHF 60 Mio
- 100% own capital funds



Posalux SA : customer references



BOSCH



DELPHI
Automotive Systems

DENSO



WUZELEM

STANADYNE



FIMTEXTILE

Valeo

7 Diesel



JAZDA

HeZe

Yan Tai

Ningbo

A.BOSTO

CRT

Common Rail Technology

Wuxi

Thank you for your attention

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