VERS UNE PRÉVISION NUMÉRIQUE DE L'ÉROSION PAR CAVITATION DANS LES MACHINES HYDRAULIQUES

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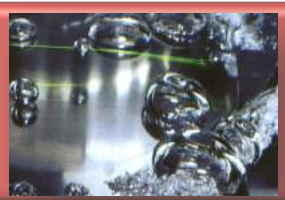
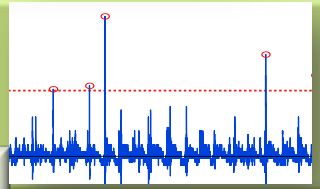
Recherches menées avec le soutien de ONR **et** GE ALSTOM

Le processus d'érosion par cavitation

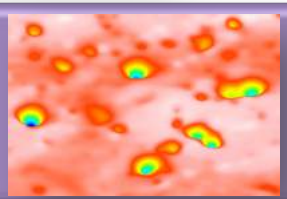
Formation
de bulles de cavitation



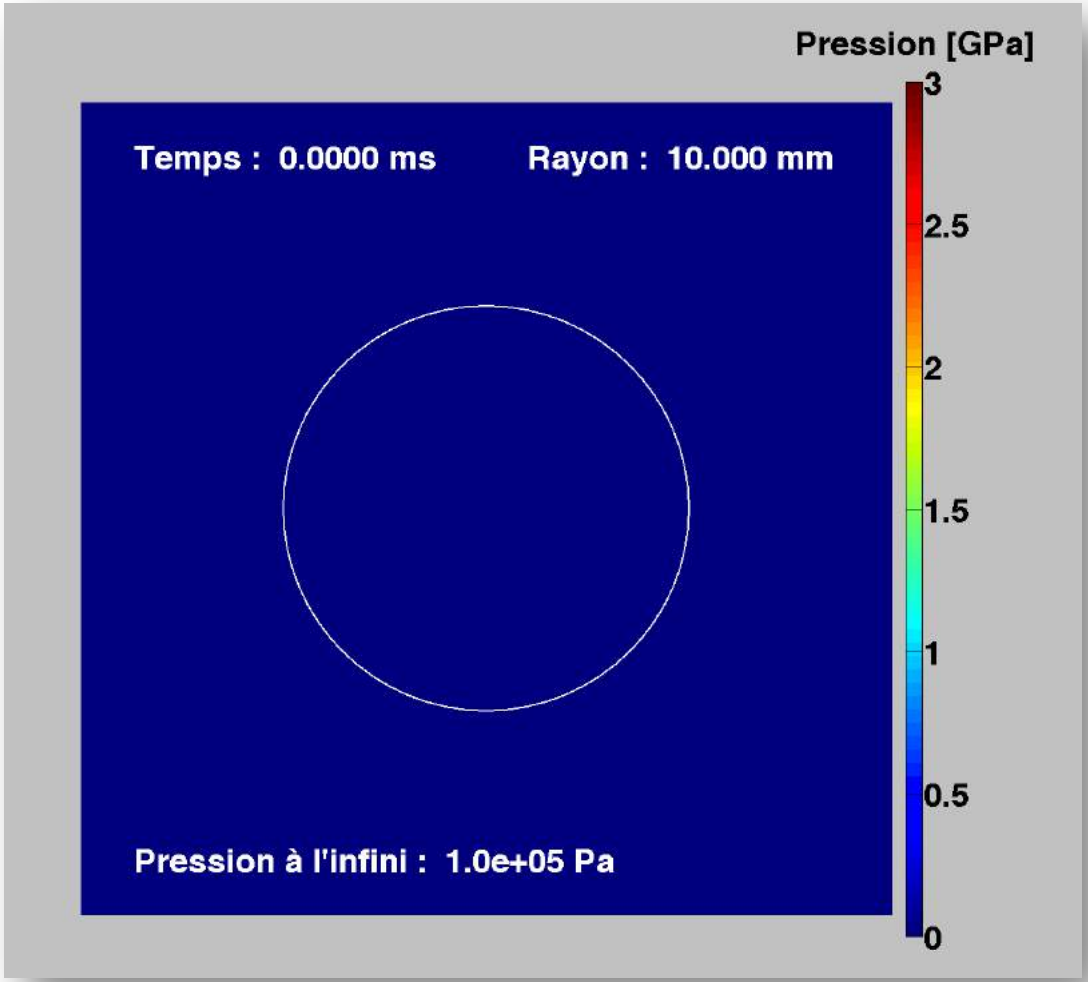
Collapse des bulles



Pitting

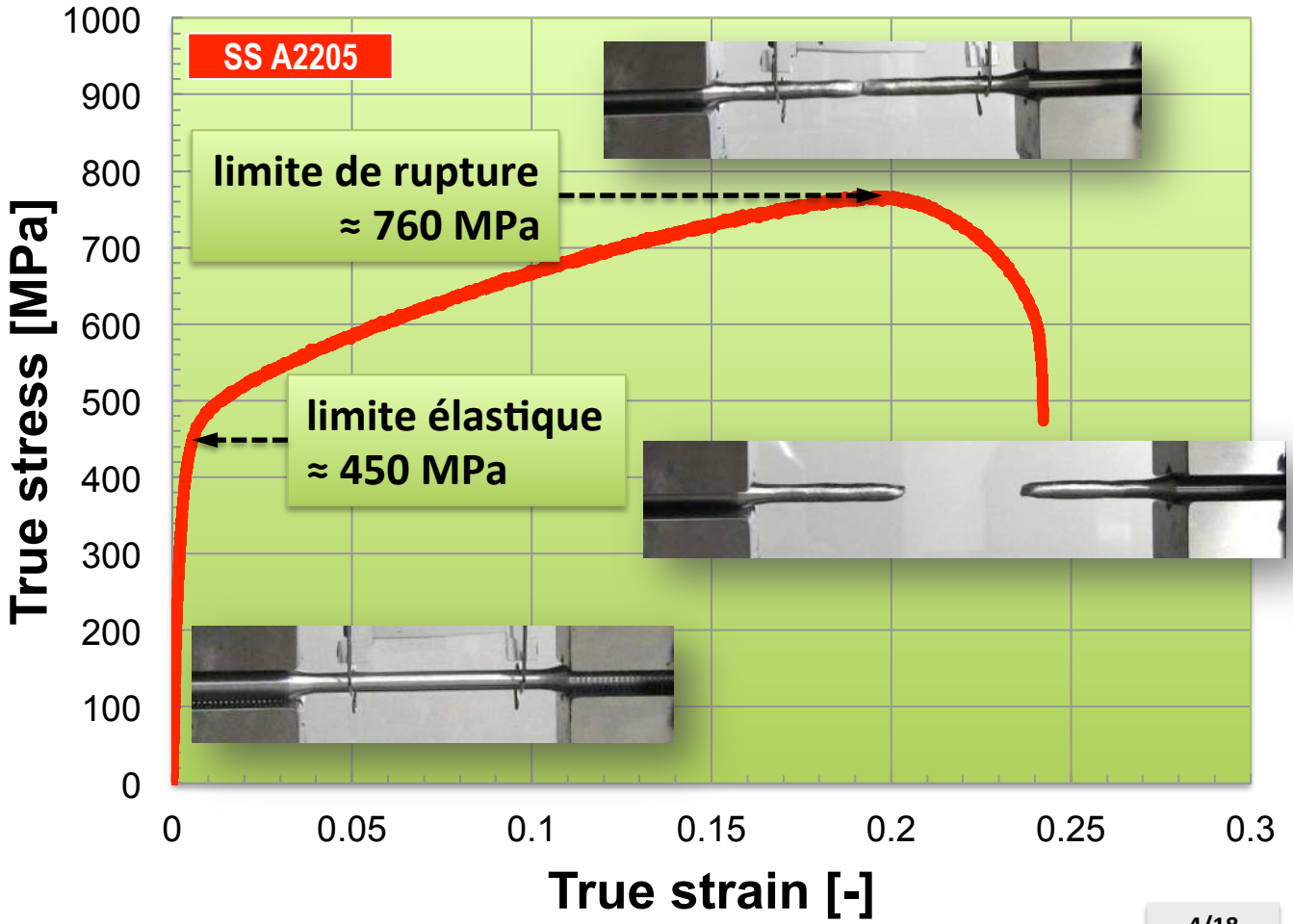


Fatigue et Perte de masse



L'implosion d'une bulle vue du côté fluide

L'implosion d'une bulle vue du côté matériau

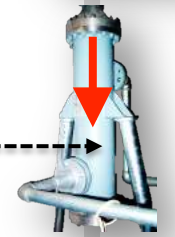


La boucle PREVERO du LEGI

Ballon de pressurisation

Section d'essais

Cuve aval

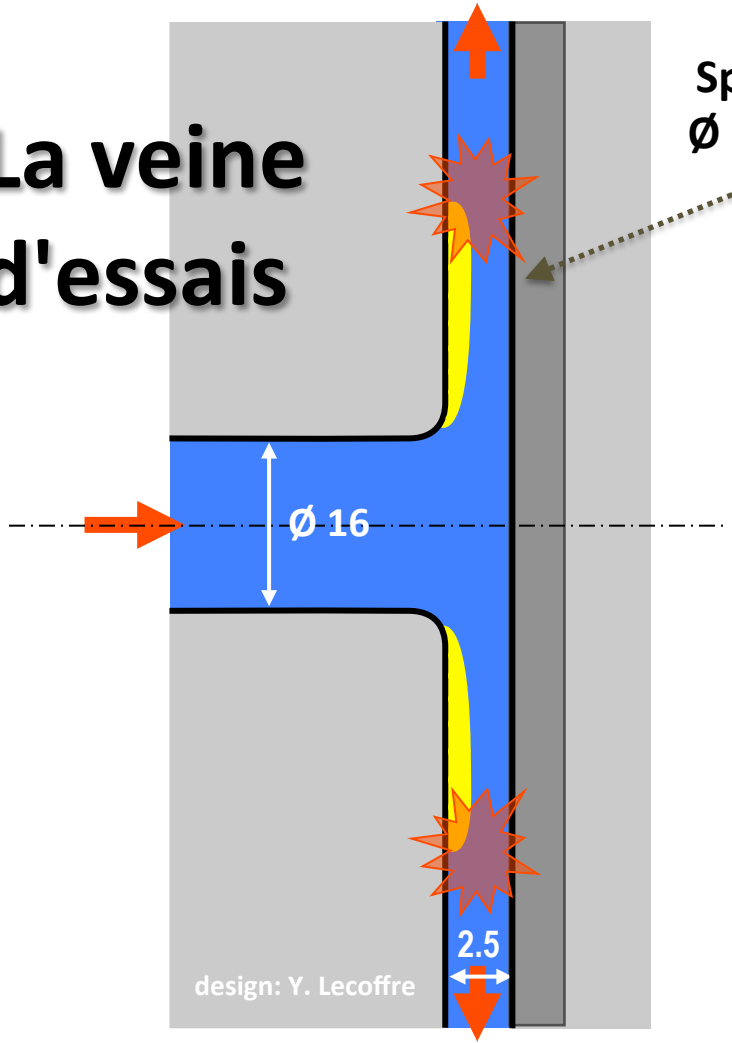


Echangeur thermique

Débit-mètre

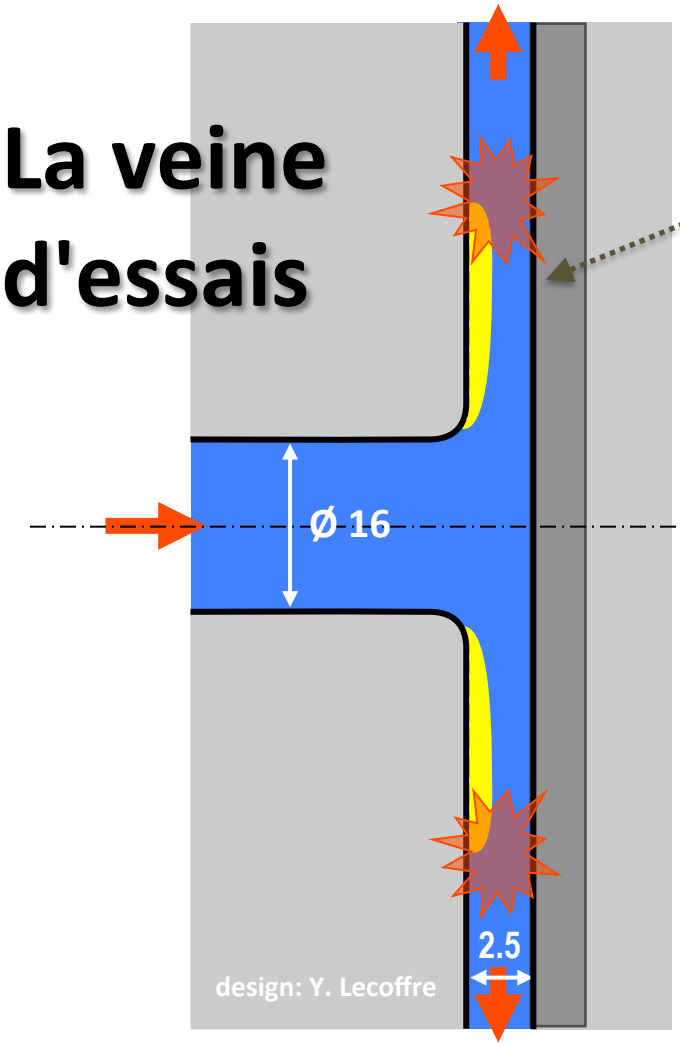
Pompe centrifuge
Moteur électrique
80 kW - 11 l/s
40 bar

La veine d'essais

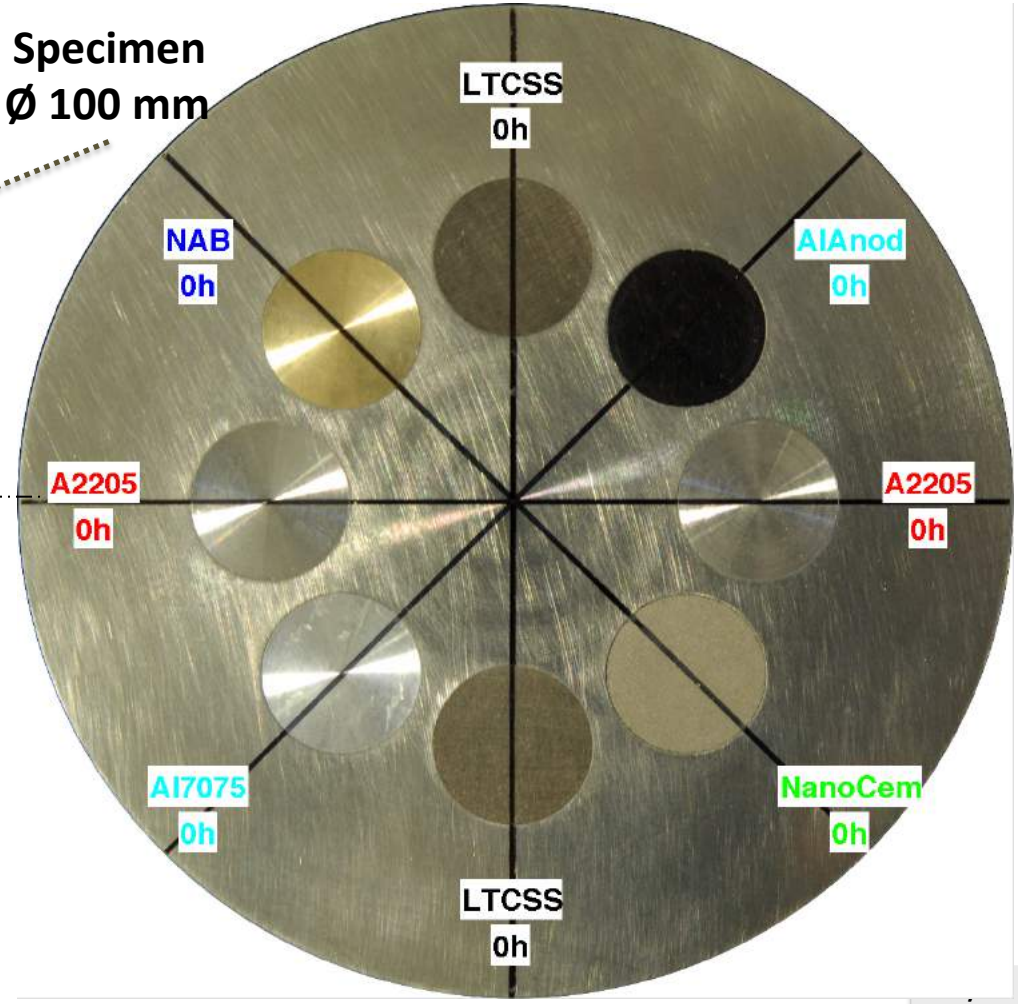


Specimen
Ø 100 mm

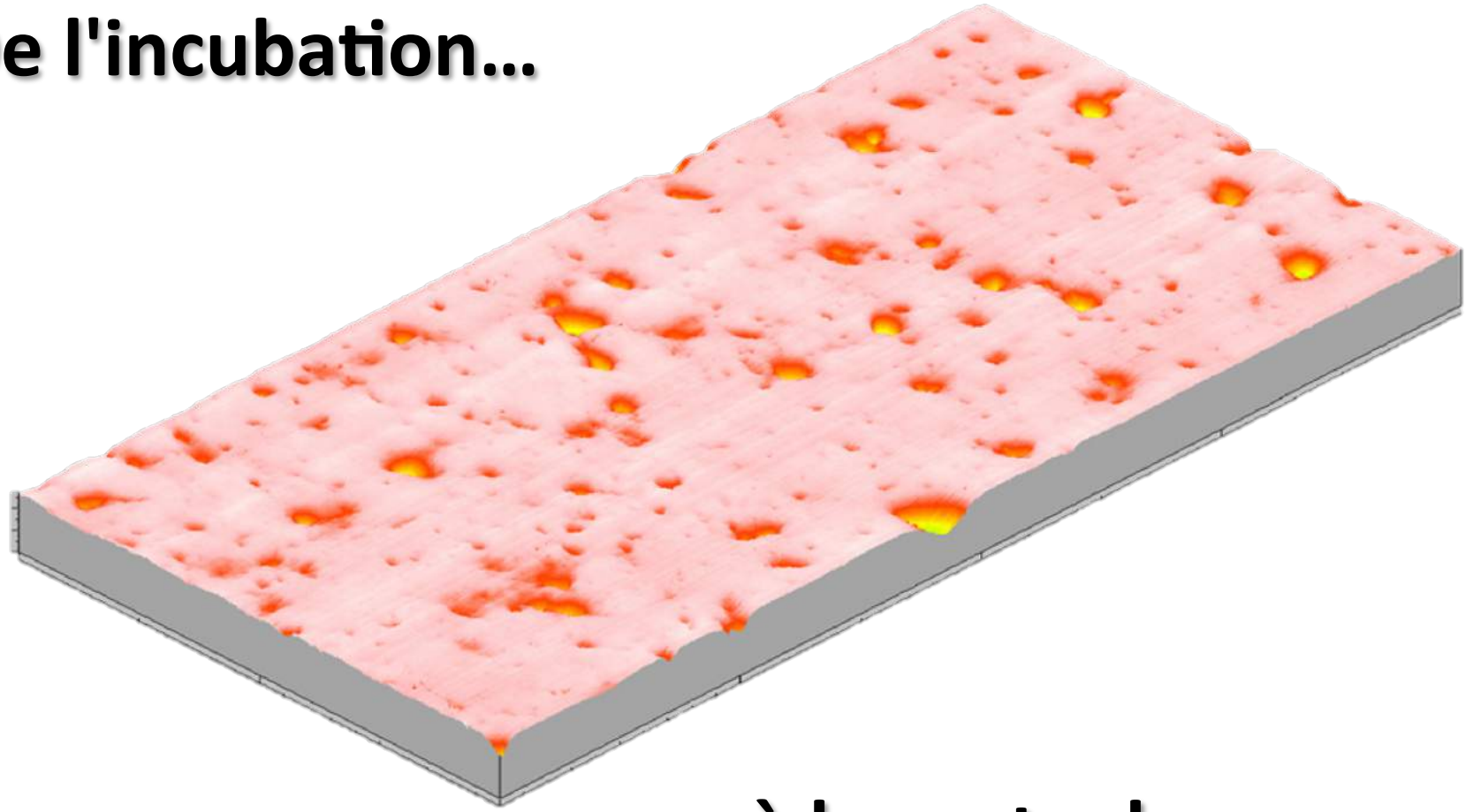
La veine d'essais



Specimen
Ø 100 mm

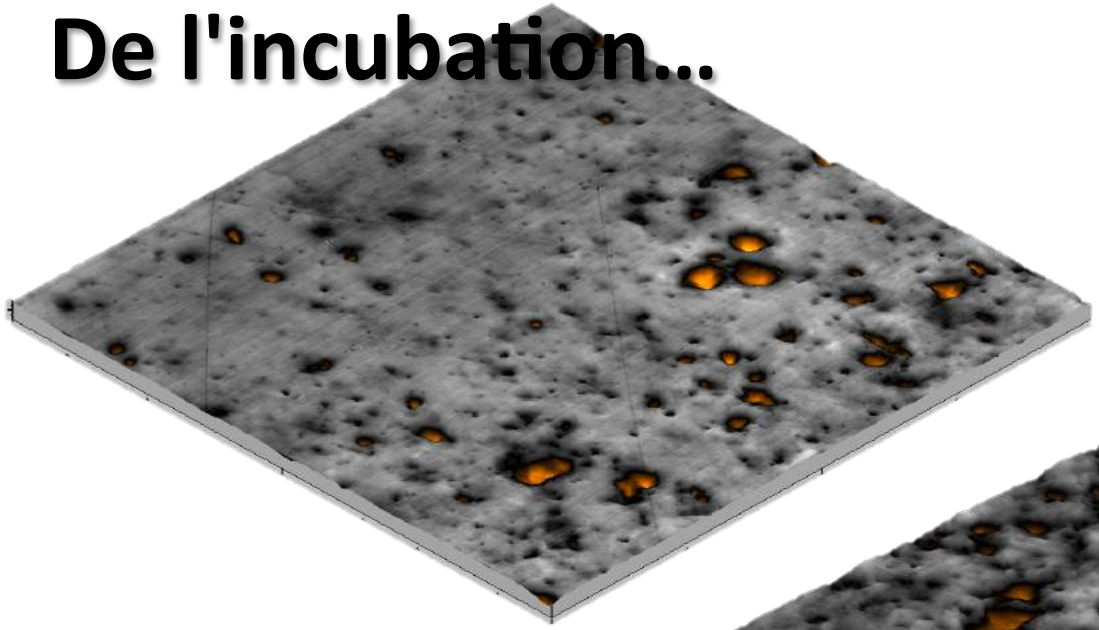


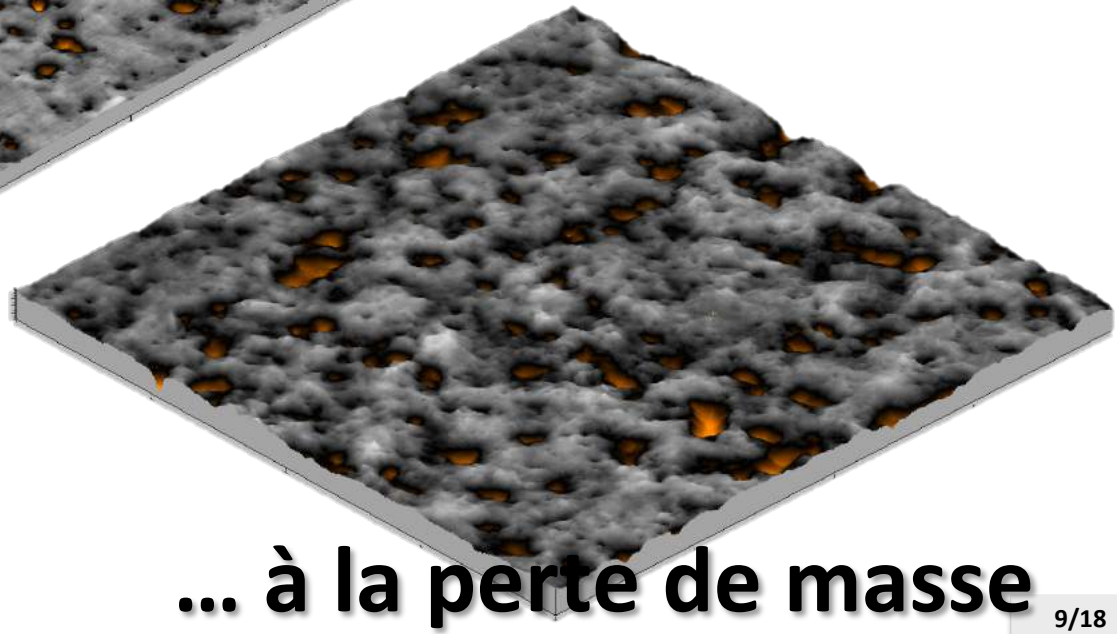
De l'incubation…



… à la perte de masse

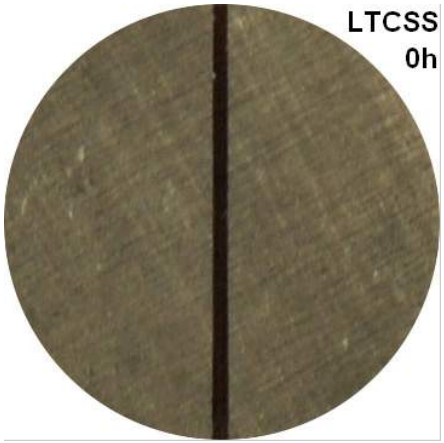
De l'incubation…

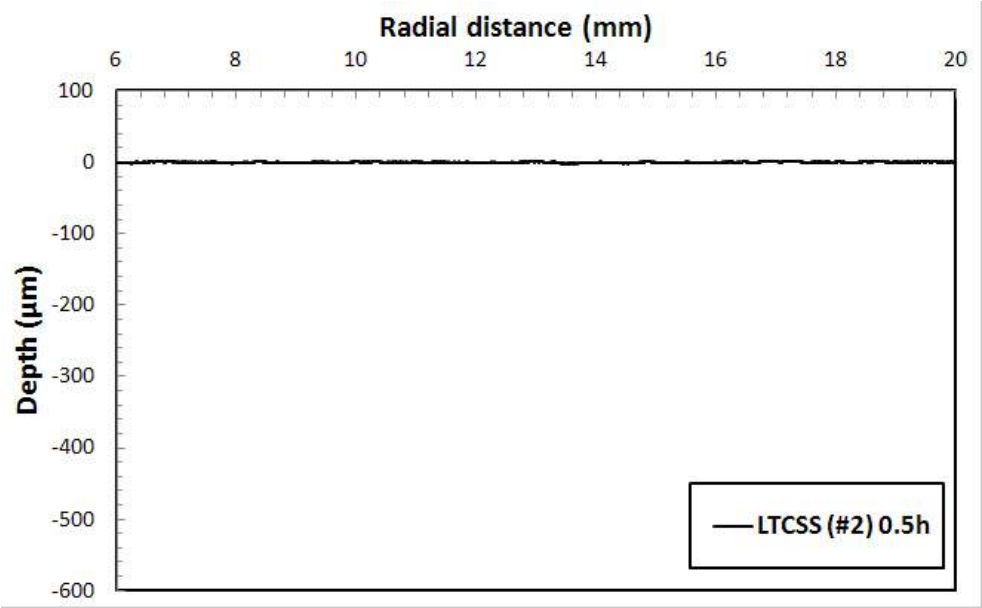




… à la perte de masse

De l'incubation…

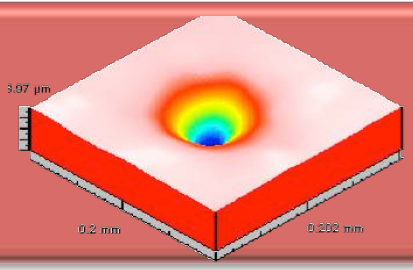




… à la perte de masse

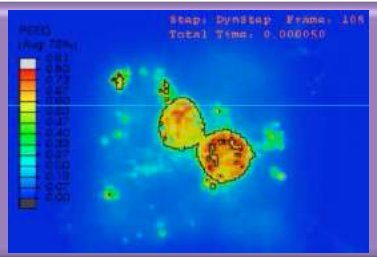
Les grandes étapes de la prévision

Caractérisation du chargement

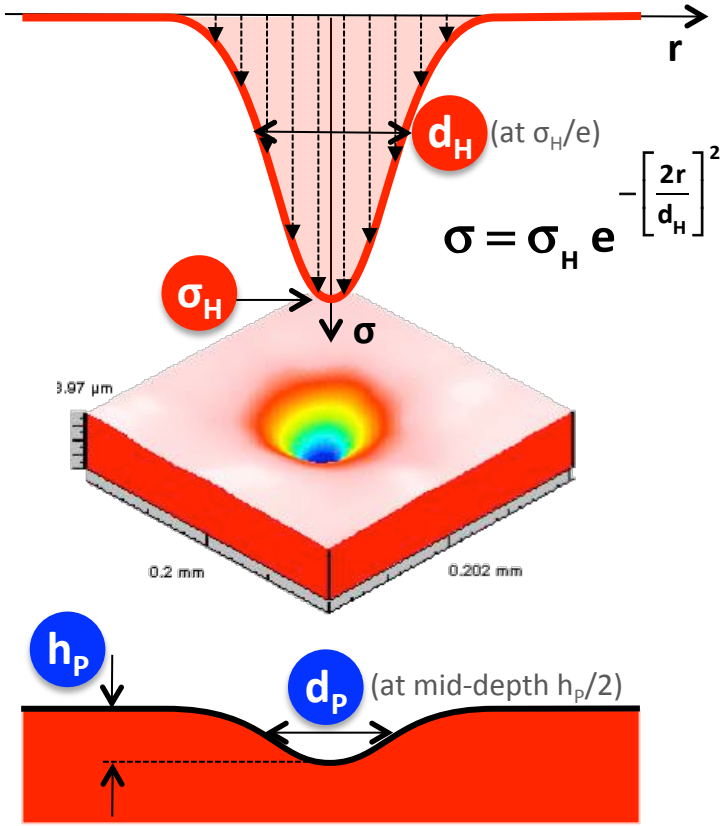


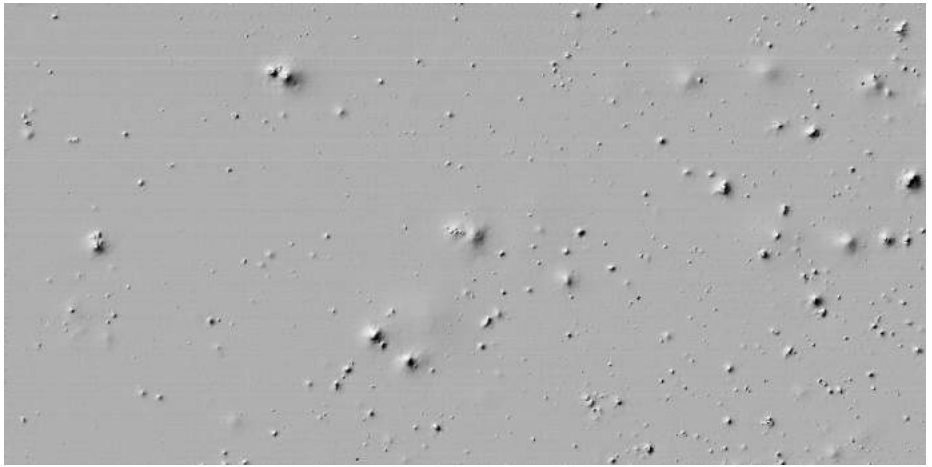
Caractérisation du matériau

Simulation FEM de la réponse du matériau



Caractérisation du chargement





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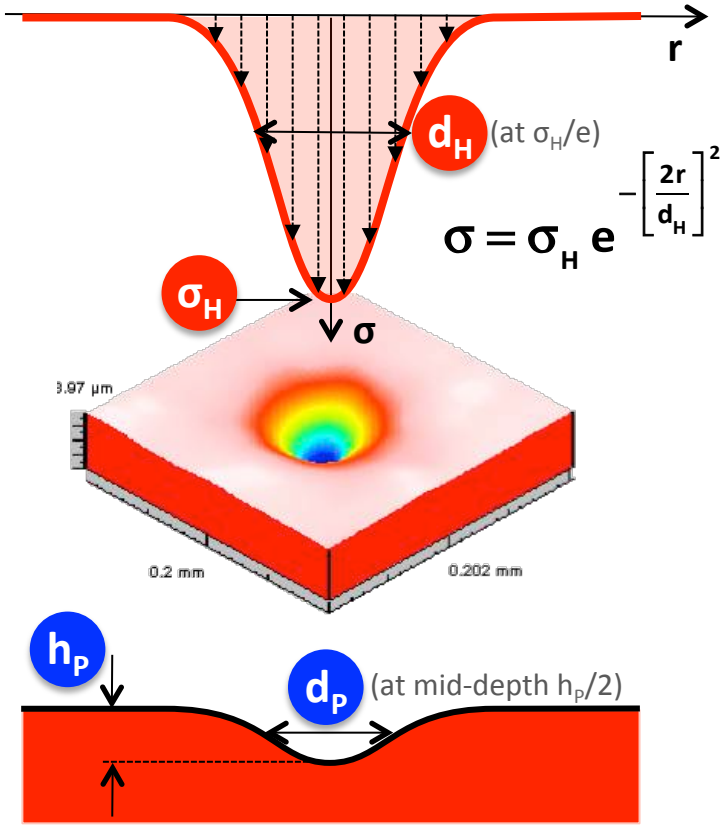
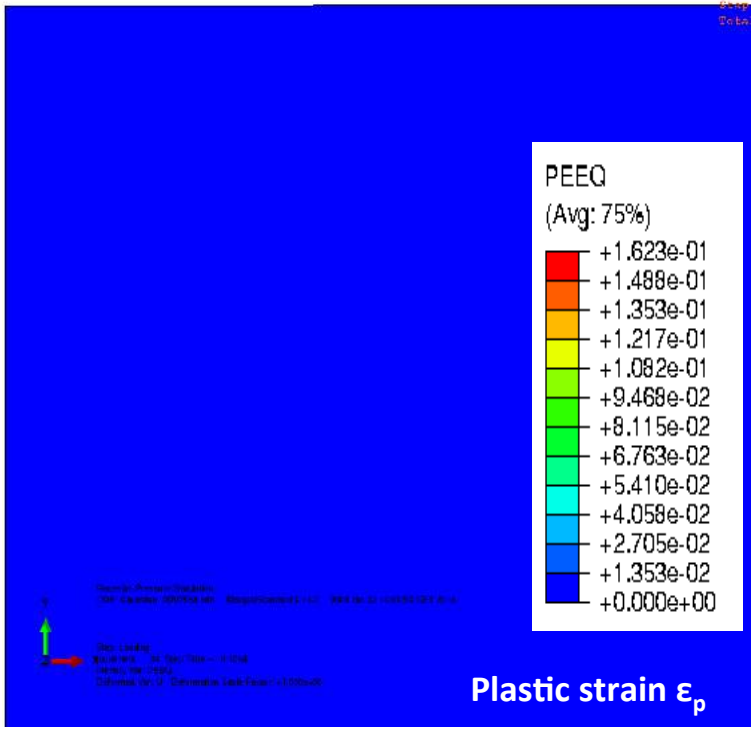
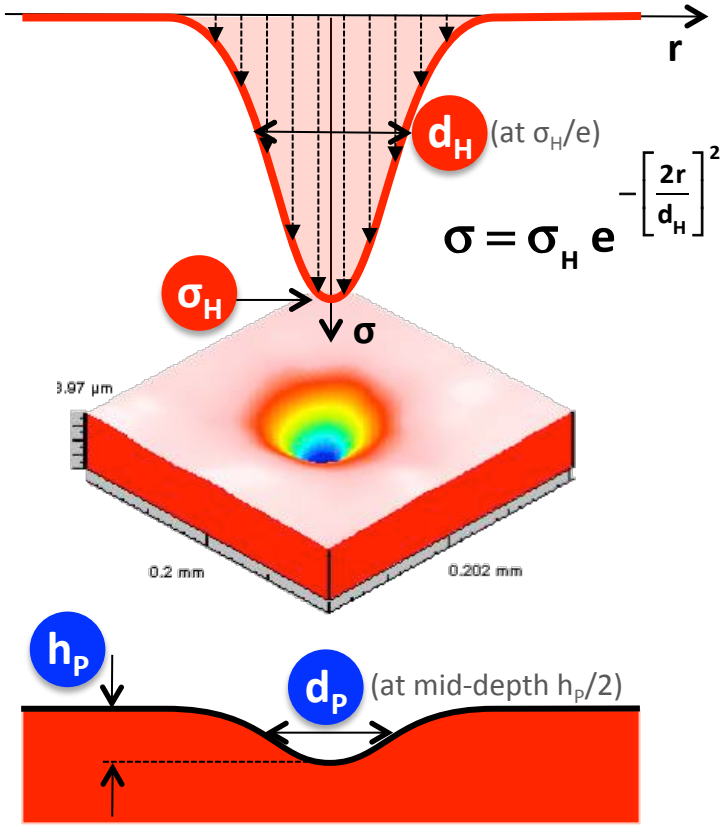
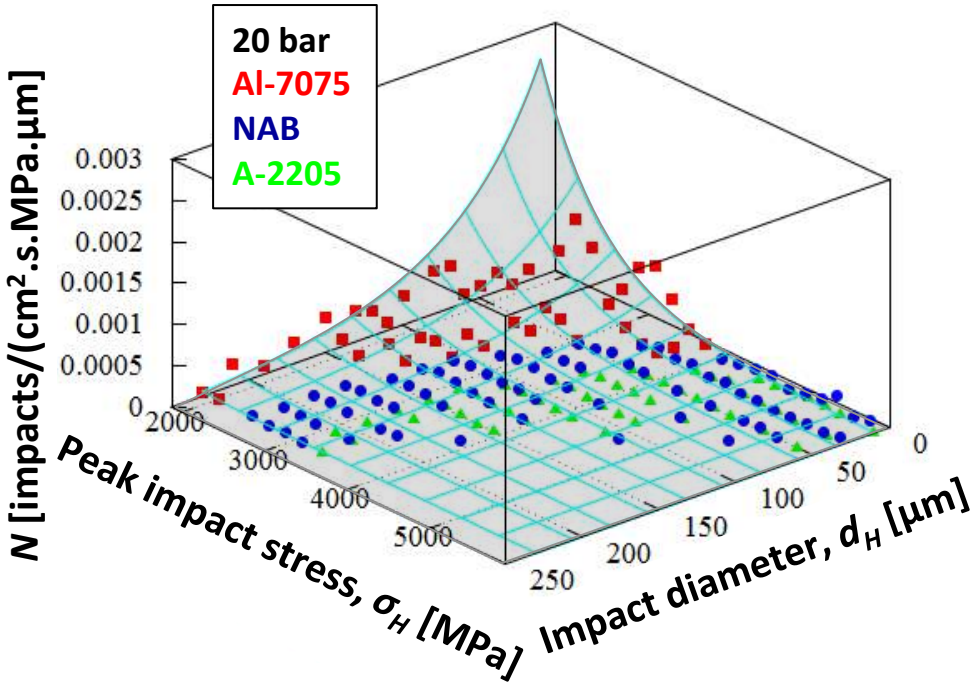




Caractérisation du chargement





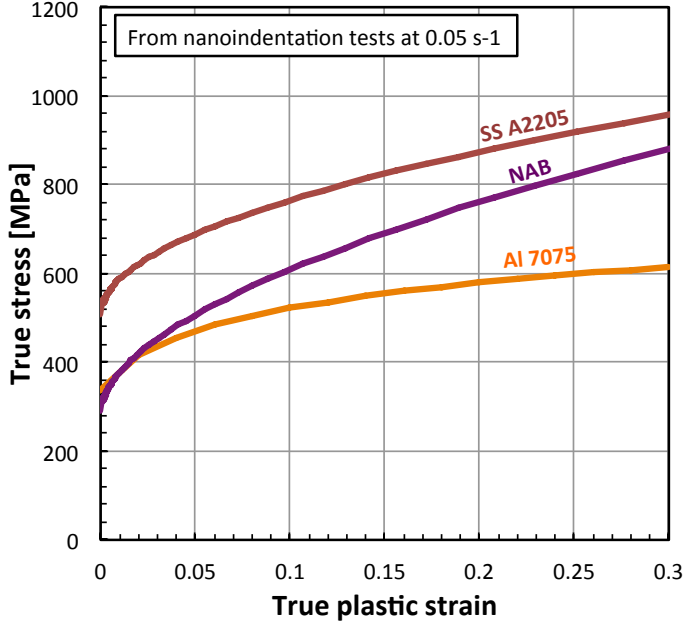
Caractérisation du matériau

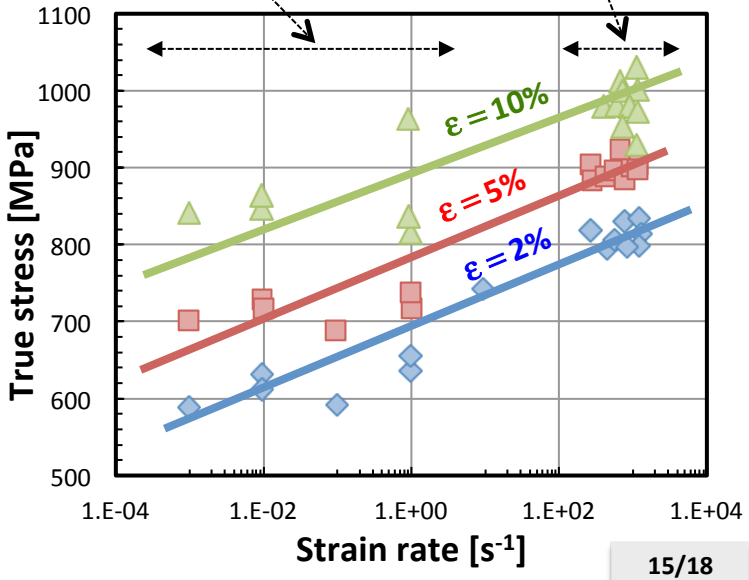
Tensile tests

Nanoindentation tests


Compression Tests (moderate strain rate)


Split Hopkinson Pressure Bar (SHPB) Tests (high strain rate)

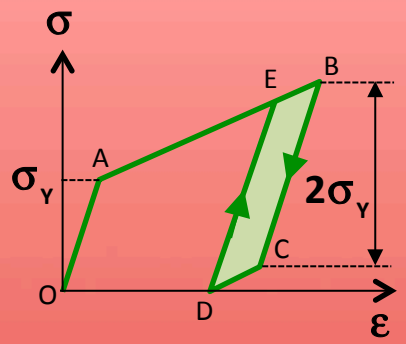




Direct numerical FEM simulation

Impact loads

Strain hardening model
(kinematic hardening, strain rate hardening…)

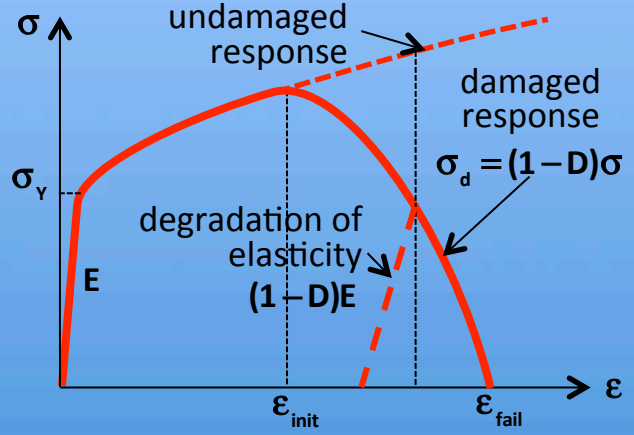


Cumul. plastic deform. ε_p

Damage model

Damage initiation ?
$\varepsilon_p > \varepsilon_{init}$
YES
NO

Failure ?
$\varepsilon_p > \varepsilon_{fail}$
YES
NO

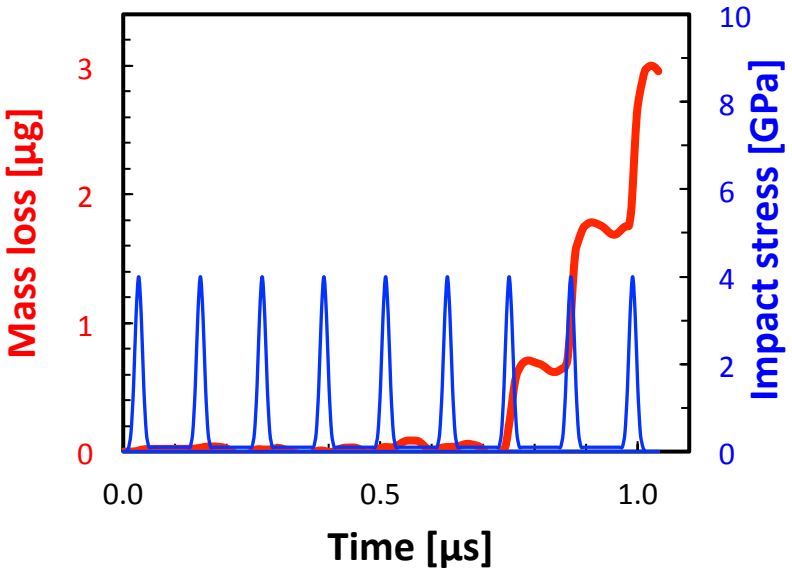


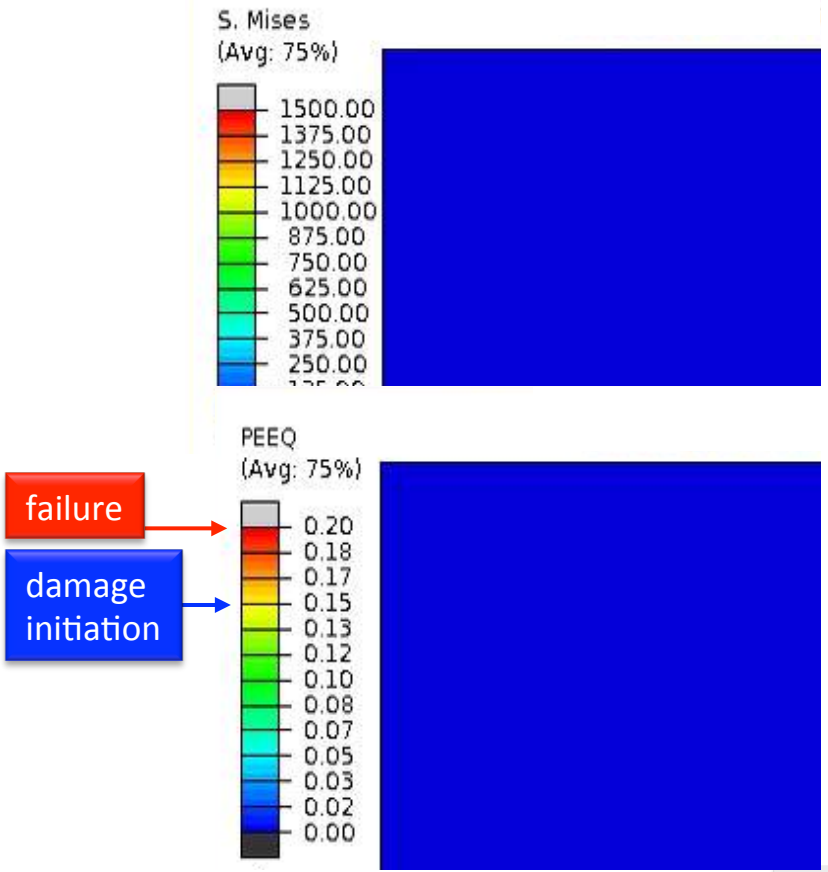
Mass loss

Direct numerical FEM simulation

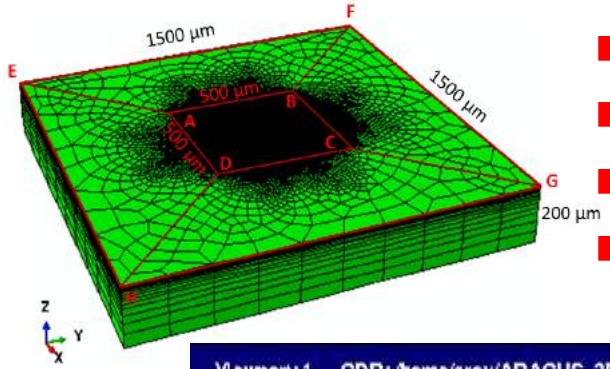
- SS A2205
- Dynamic/Explicit, Johnson-Cook model
- $\sigma = \sigma_H e^{-(r/r_H)^2} e^{-(t/t_H)^2}$

σ_H = 4 GPa
r_H = 40 µm
$t_H = 10^{-8}$ s = 10 ns





Direct numerical FEM simulation



- Flow pressure: 20 bar
- Dynamic/Explicit analysis
- Material: A-2205
- Johnson-Cook model
- Impact duration, $t_H = 10^{-8}$ s
- **Total number of impacts = 420**
- **Damage initiation after ≈ 360 impacts**