

EFFET DE PROCÉDÉS AVANCÉS DE RECHARGEMENT DES SURFACES SUR LES MÉCANISMES DE DÉFORMATION ET USURE DES OUTILLAGES DE FORGEAGE À CHAUD DES PIÈCES AÉRONAUTIQUES

E. CABROL

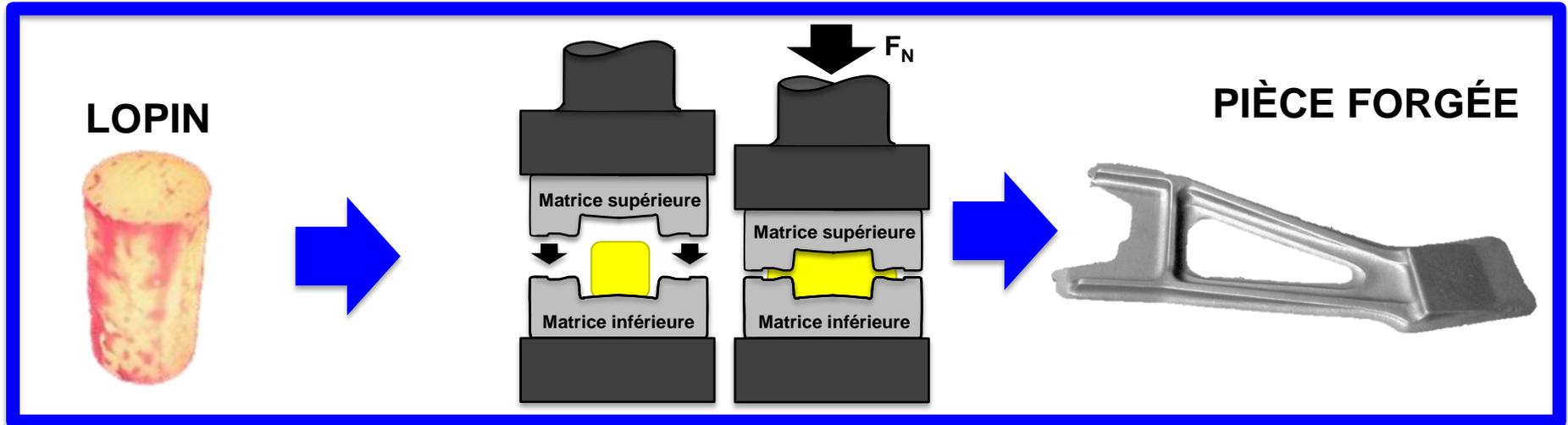
C. BOHER, V. VIDAL, F. REZAÏ-ARIA, F. TOURATIER



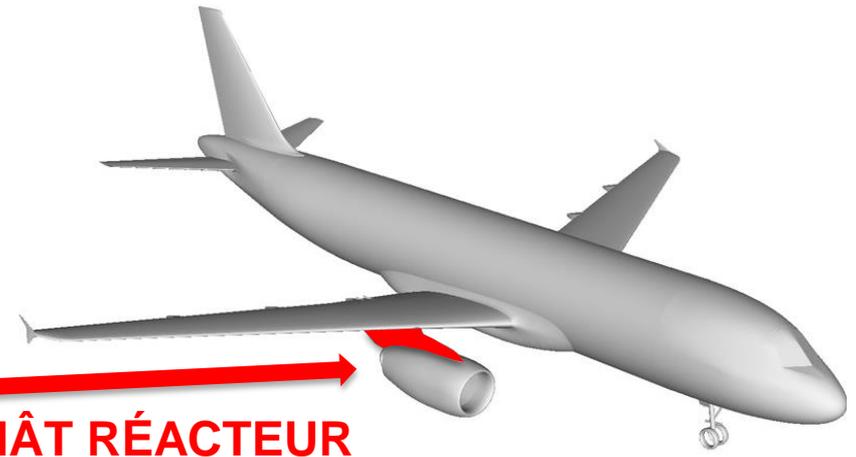
Contexte industriel

Forgeage à chaud de pièces pour l'aéronautique

FORGEAGE À CHAUD



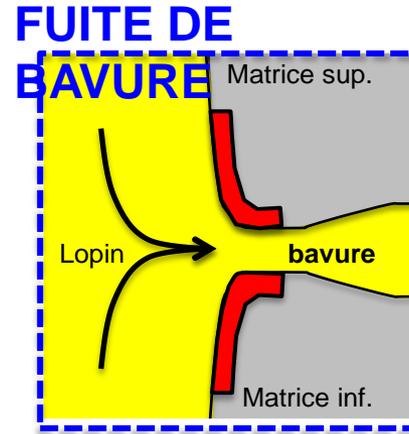
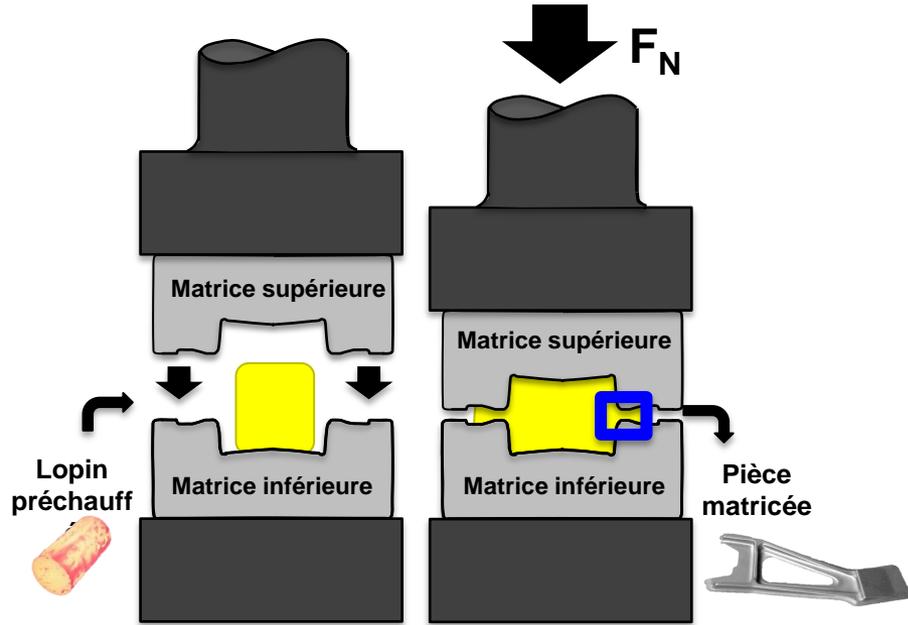
TTH
USINAGE
ASSEMBLAGE



MÂT RÉACTEUR

Contexte industriel

Forgeage à chaud de pièces pour l'aéronautique



RENFORCEMENT LOCAL

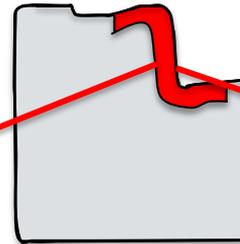


Glissement lopin/matrice

Stellite 21
ÉCOULEMENT MIG
PLASTIQUE

Projet FUI

ROOF : Revêtements Optimisés pour Outillages de Forge



MATÉRIAUX

Nouveaux matériaux

- ↘ ↙
- ↗ $R_{p0,2}$ en température
- ↘ f
- Bonne adhérence

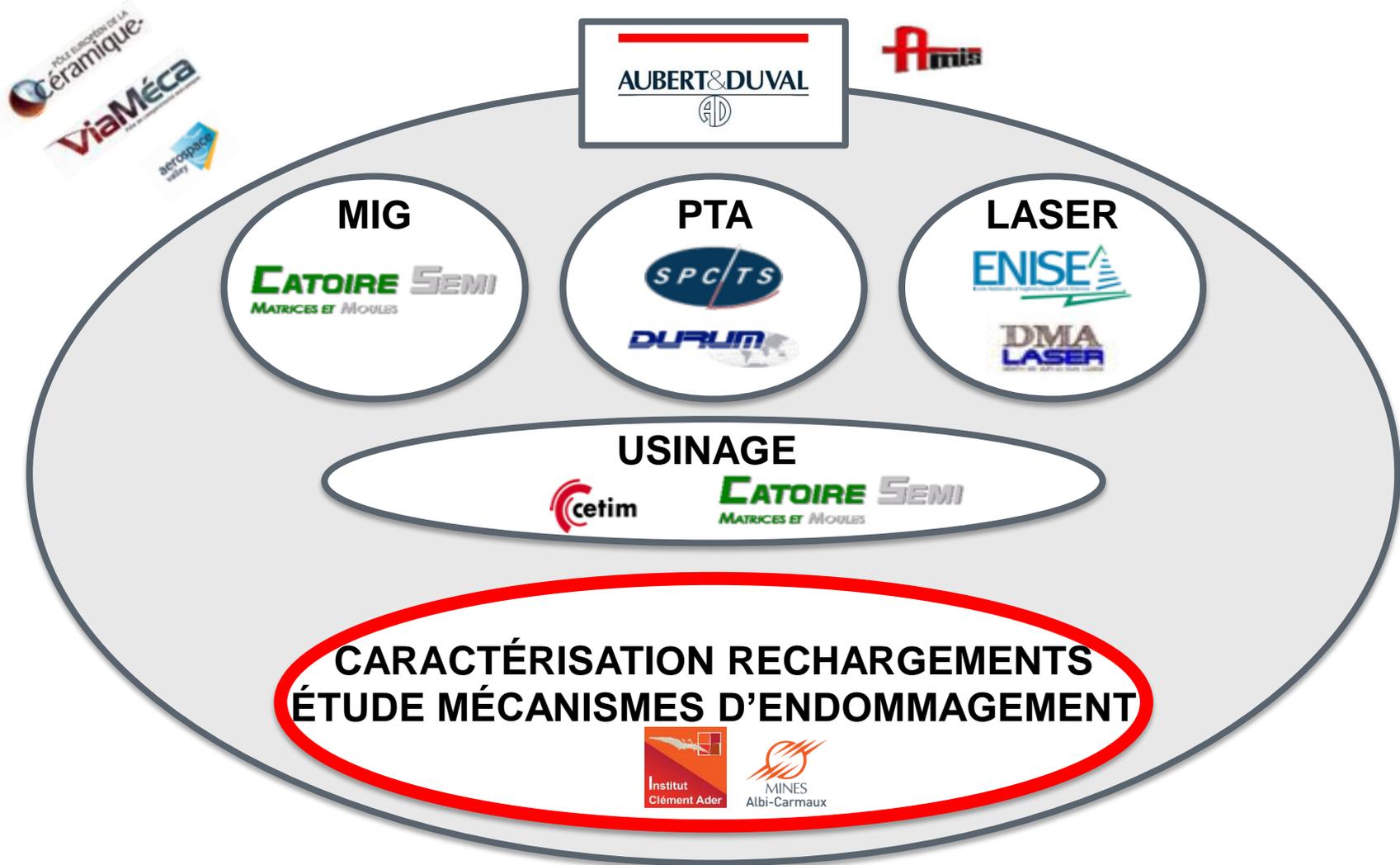
PROCÉDÉS

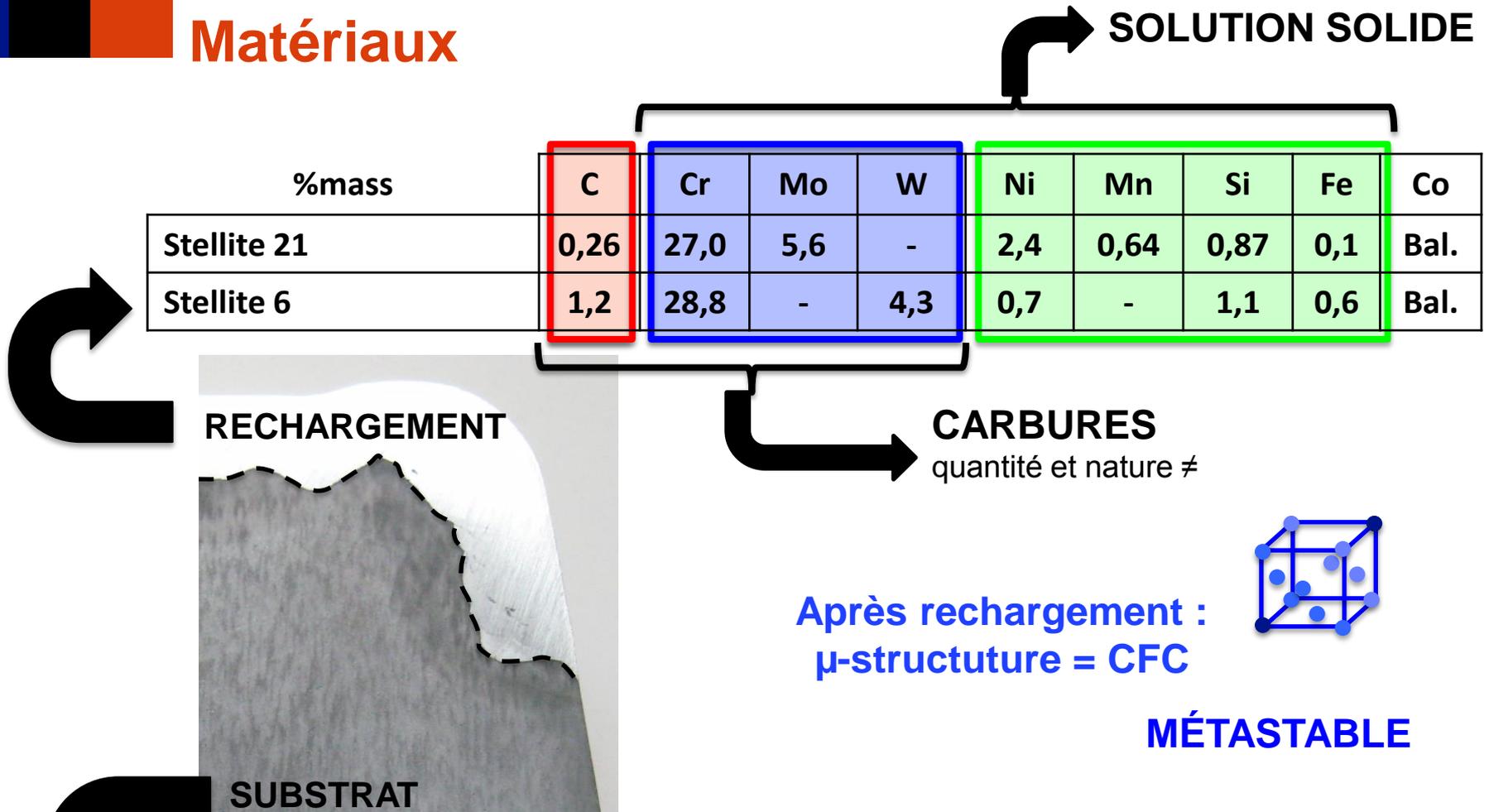
Nouveaux procédés : PTA et LASER

- Automatiser
- Dépôt multi-matériaux

Projet FUI

ROOF : Revêtements Optimisés pour Outillages de Forge

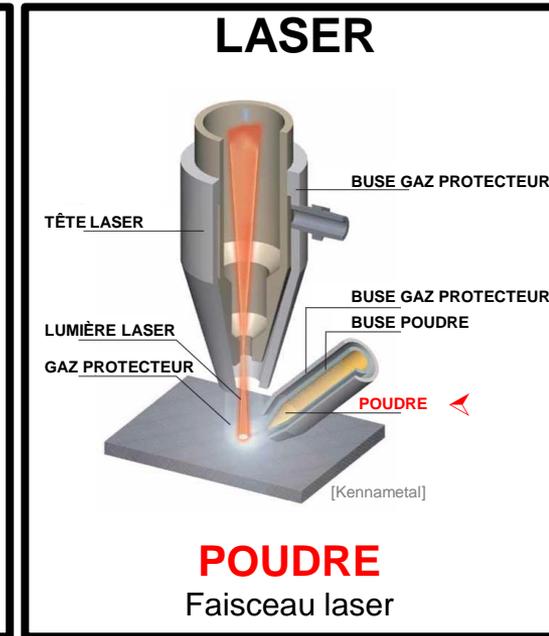
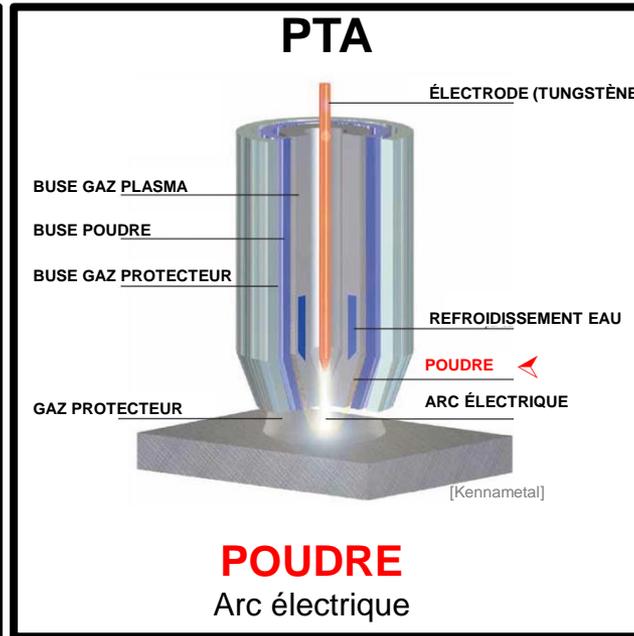
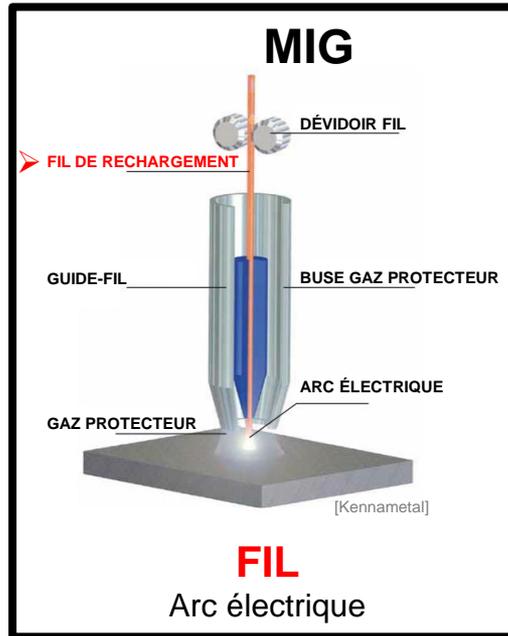




Stellites gardent structure CFC métastable à T_{ambiante}
 Stellites faible EDE ($10\text{-}50 \text{ mJ/m}^2$)
 EDE dépend des éléments d'alliages :

Fe, Mn, Ni, C stabilisent structure CFC and ↗ EDE
 Cr, Mo, W, Si stabilisent structure HC and ↘ EDE

Procédés



Stellite 21 (ST21)

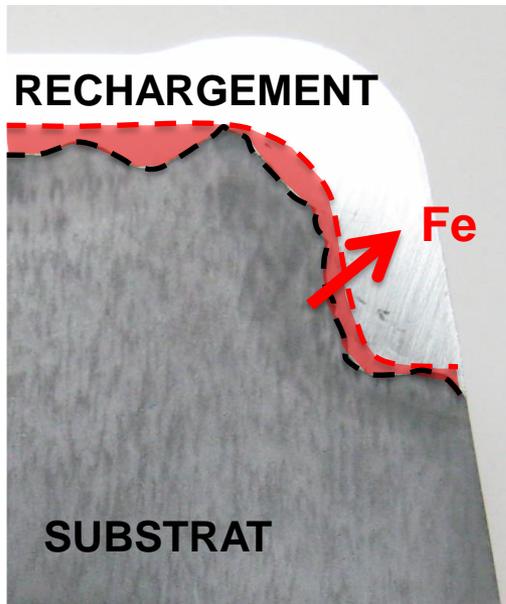
Stellite 21 (ST21)
Stellite 6 (ST6)

Stellite 21 (ST21)
Stellite 6 (ST6)

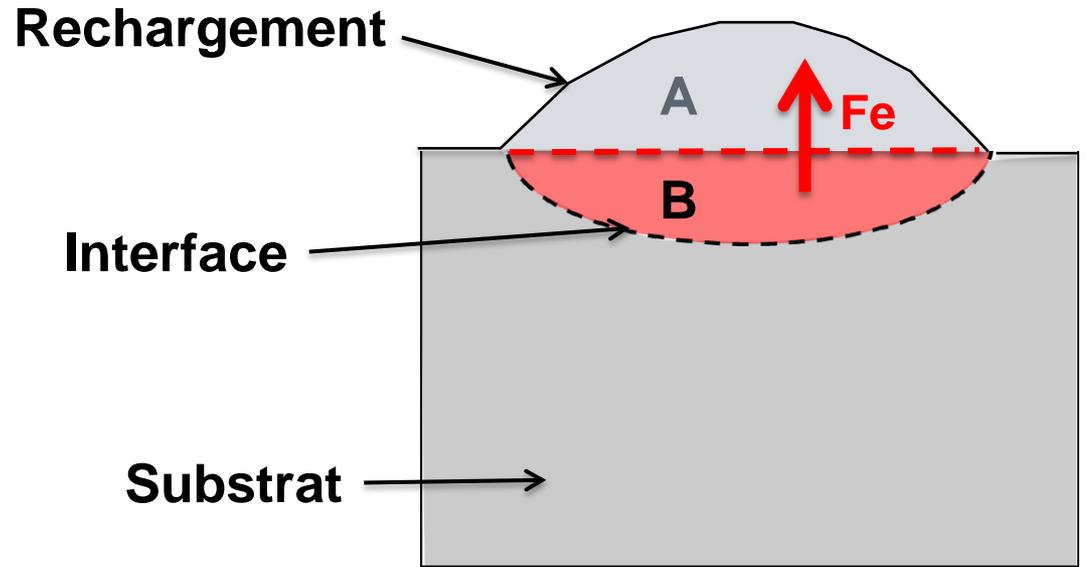
	MIG	PTA	LASER
Apport d'énergie	++++	++	+

[Levêque, R. (2007), Traitements et revêtements de surface des métaux (p. 243)]

Dilution du Fe



Stellite 21
MIG



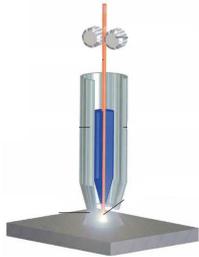
A = volume de matériau d'apport
B = volume de substrat fondu



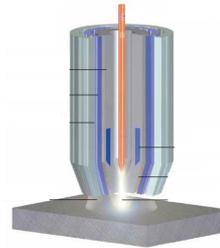
TENEUR EN FER

Microstructure : *influence du procédé*

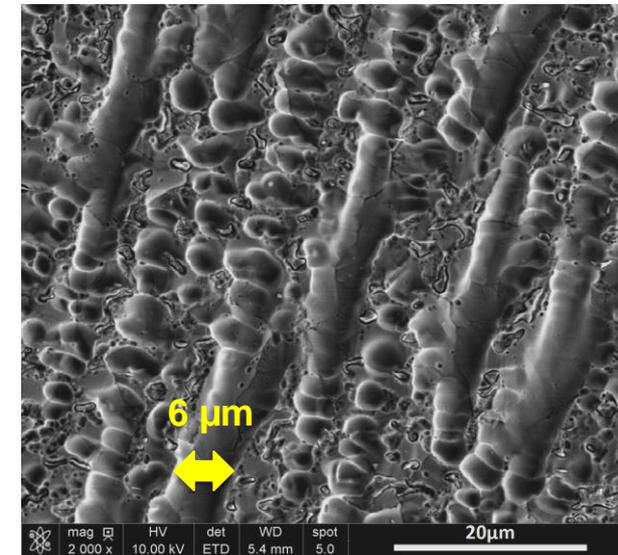
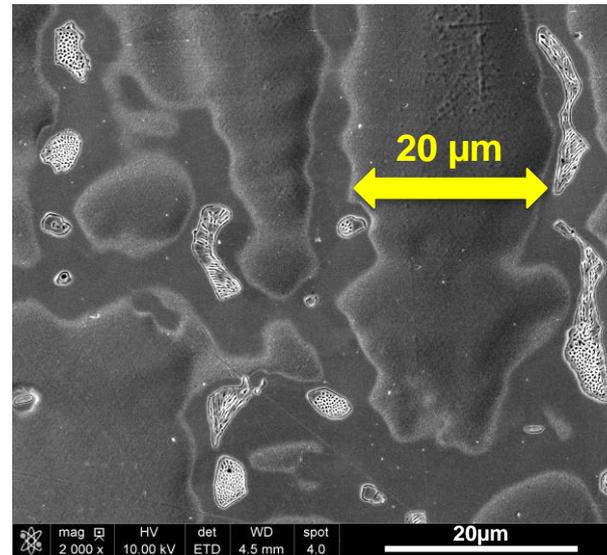
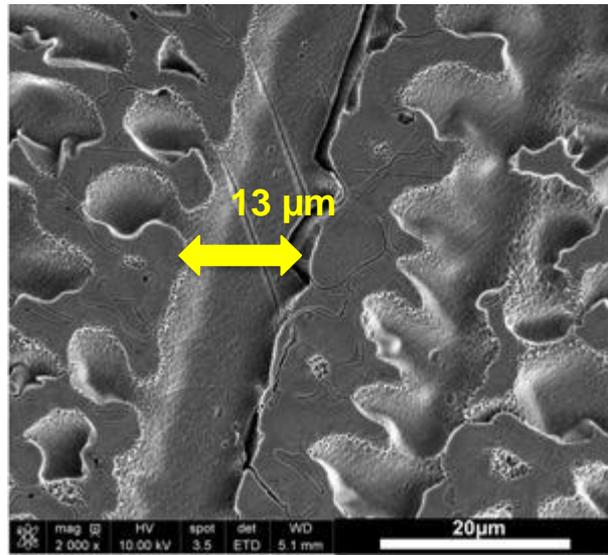
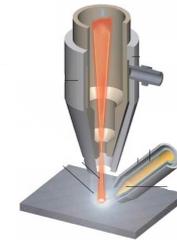
MIG



PTA

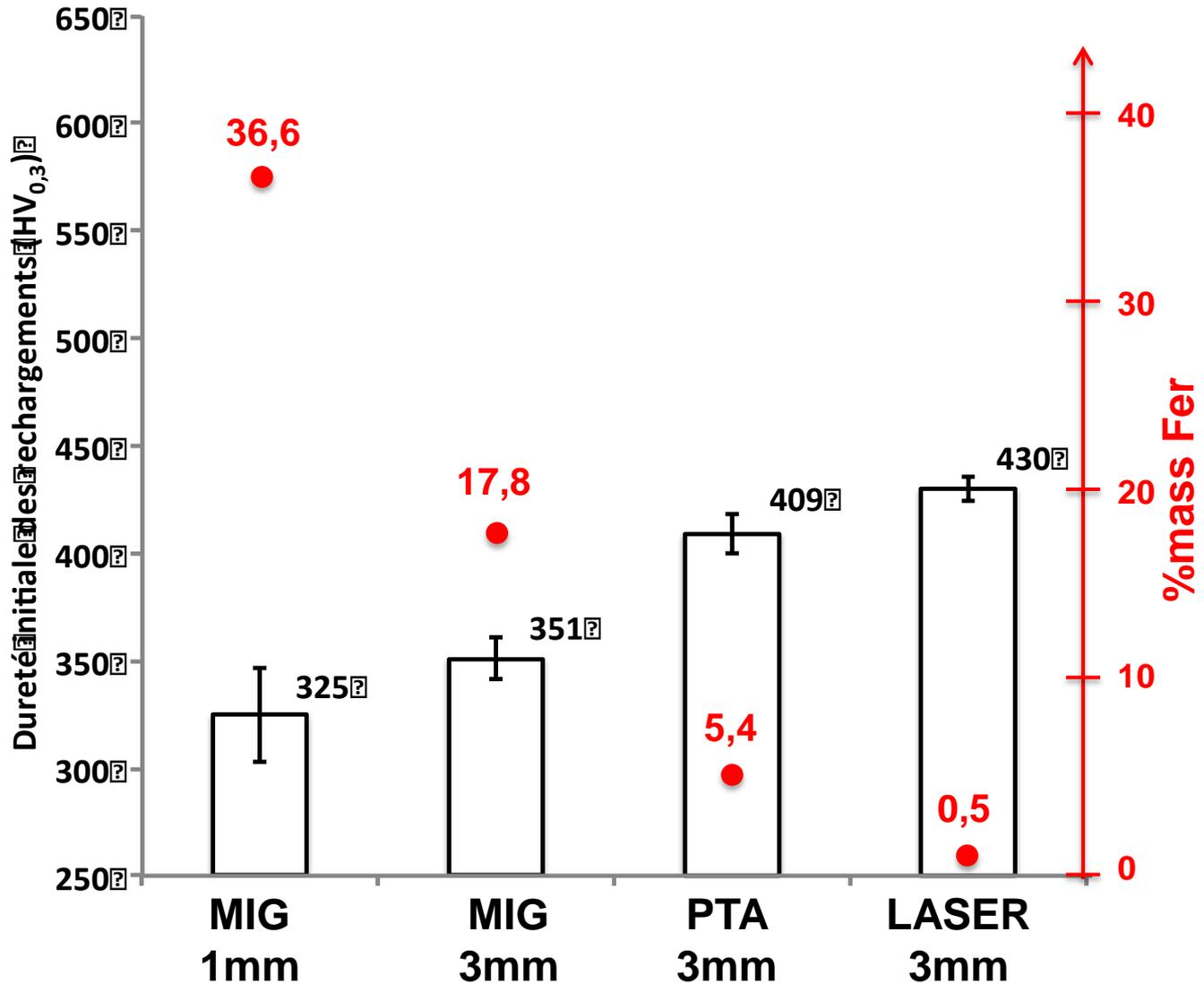


LASER



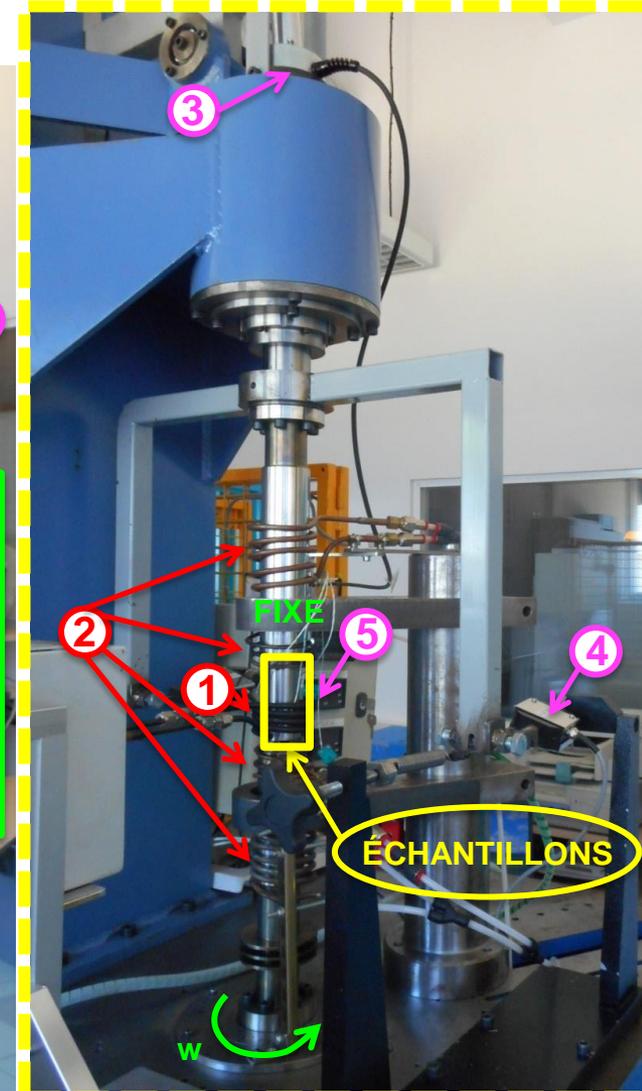
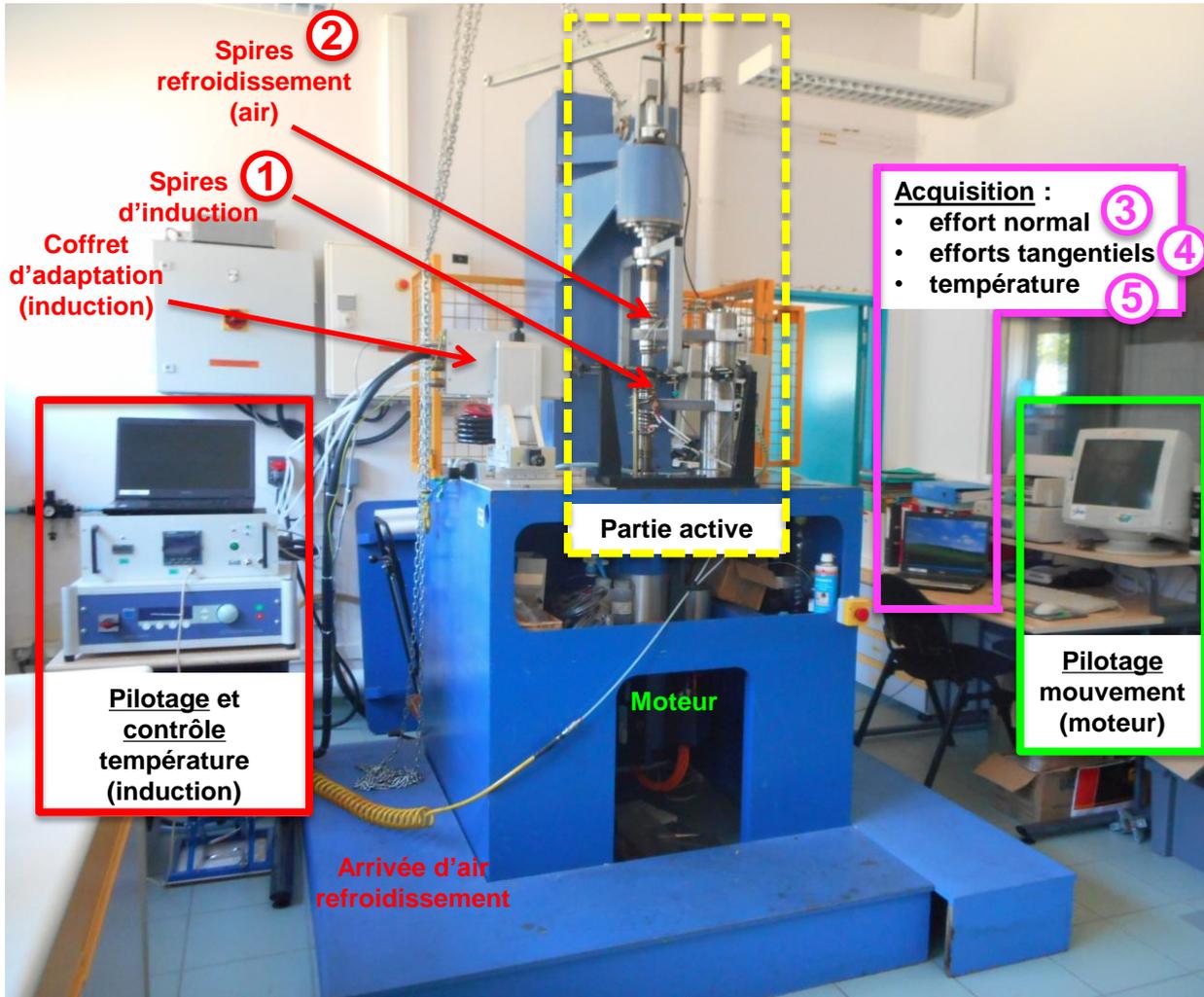
Dureté : Dilution & Teneur en fer

Stellite 21

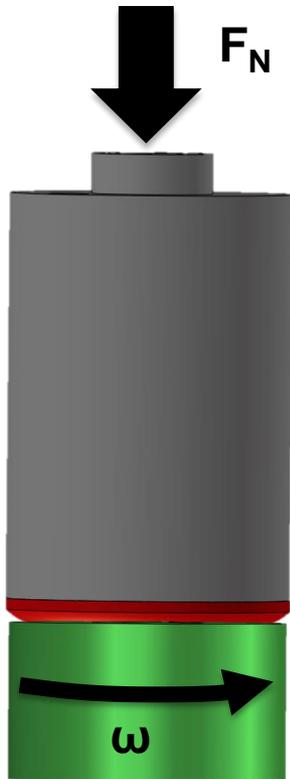
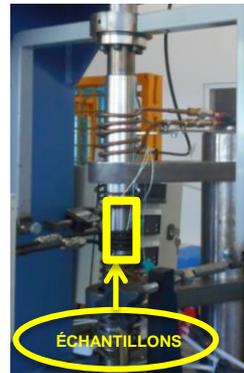


Tribomètre fortes charges à chaud

PARTIE ACTIVE



Échantillons et paramètres d'essais

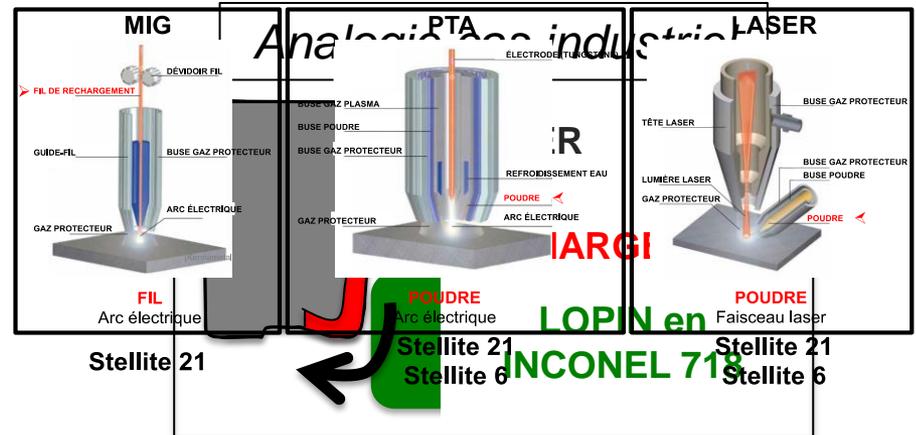


**ACIER
(AD820)**

RECHARGEMENT

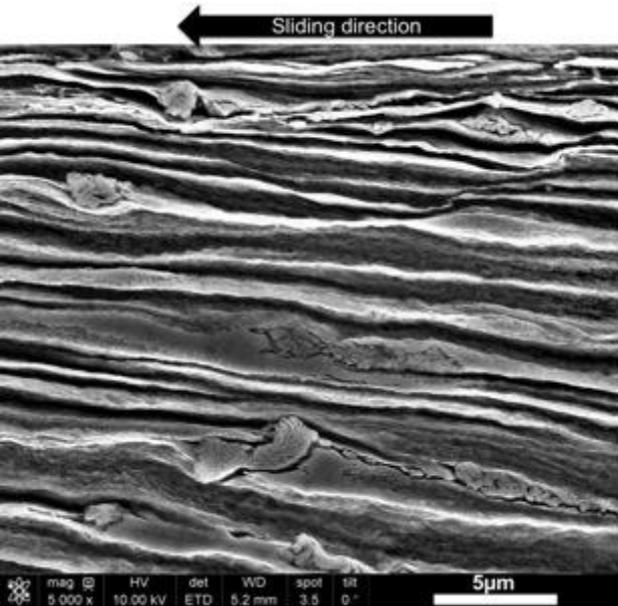
INCONEL 718

Température initiale du contact (°C)	20, 450, 600
Charge normale (daN)	800
Vitesse de rotation (mm/sec)	5
Distance de glissement (m)	4

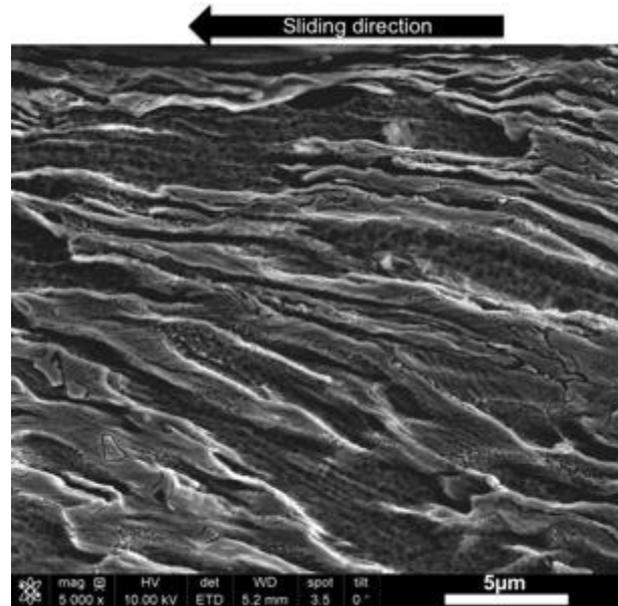


Déformation plastique de la surface des rechargements

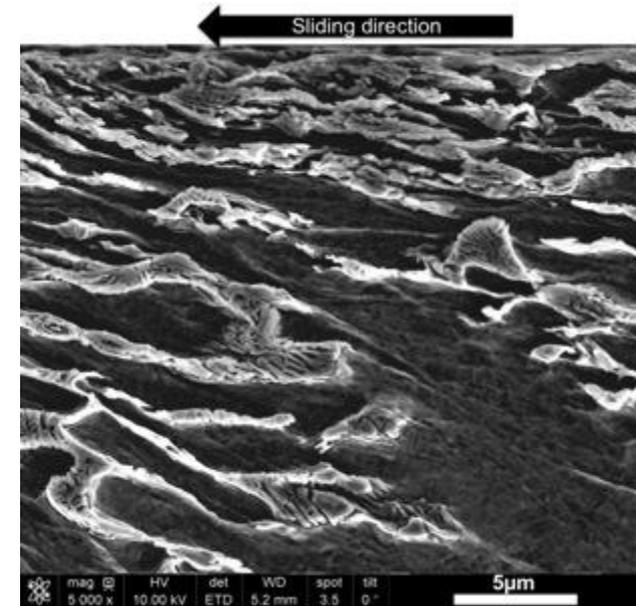
ST21-MIG



ST21-LASER



ST6-LASER



Dendrites: large plastic flow

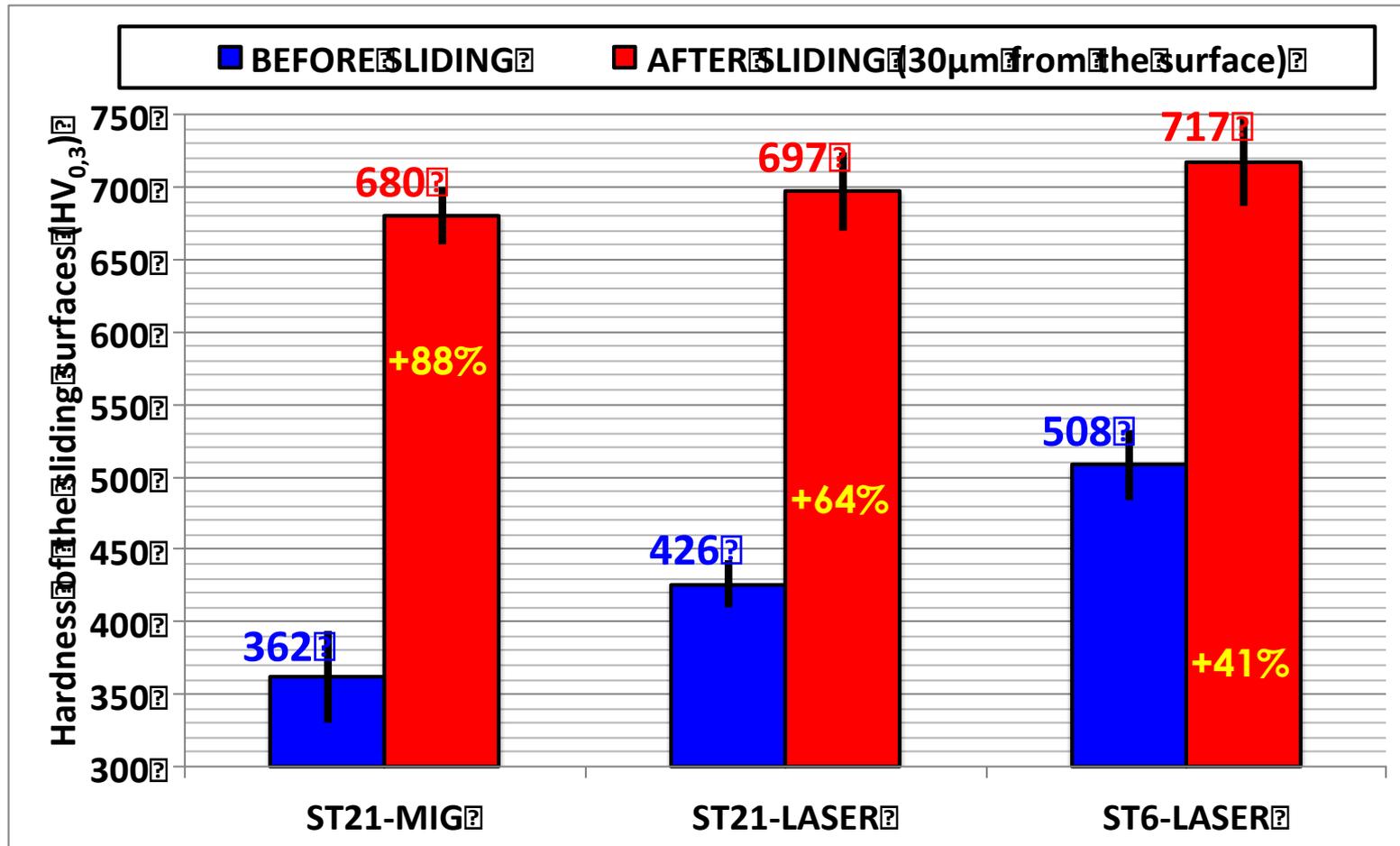
Main velocity accommodation mechanism

=

shearing of dendritic and interdendritic spaces.

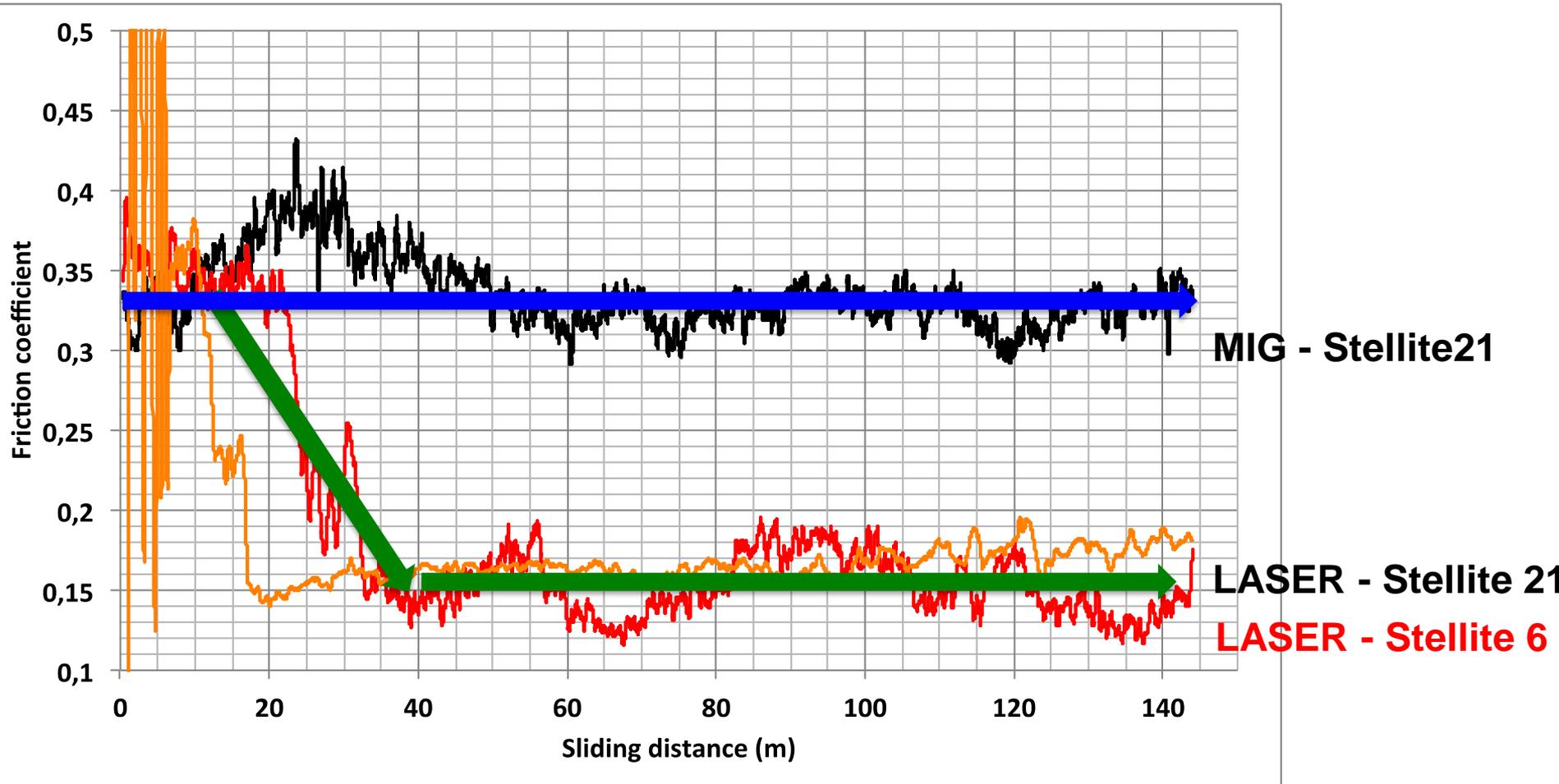
Grain reorientation according to the sliding direction

Ecrouissage sous sollicitations tribologiques



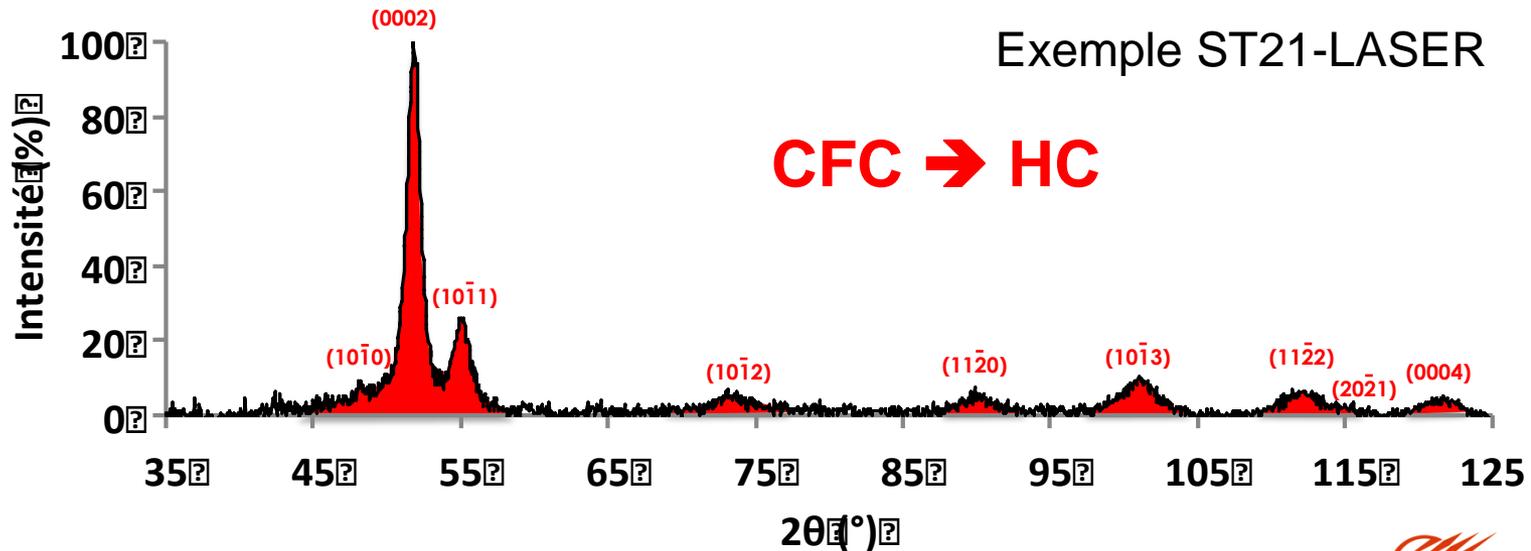
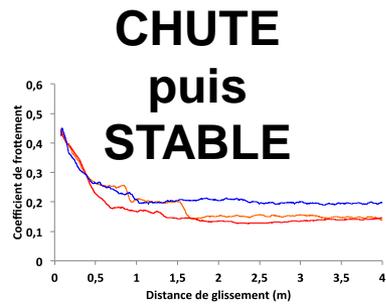
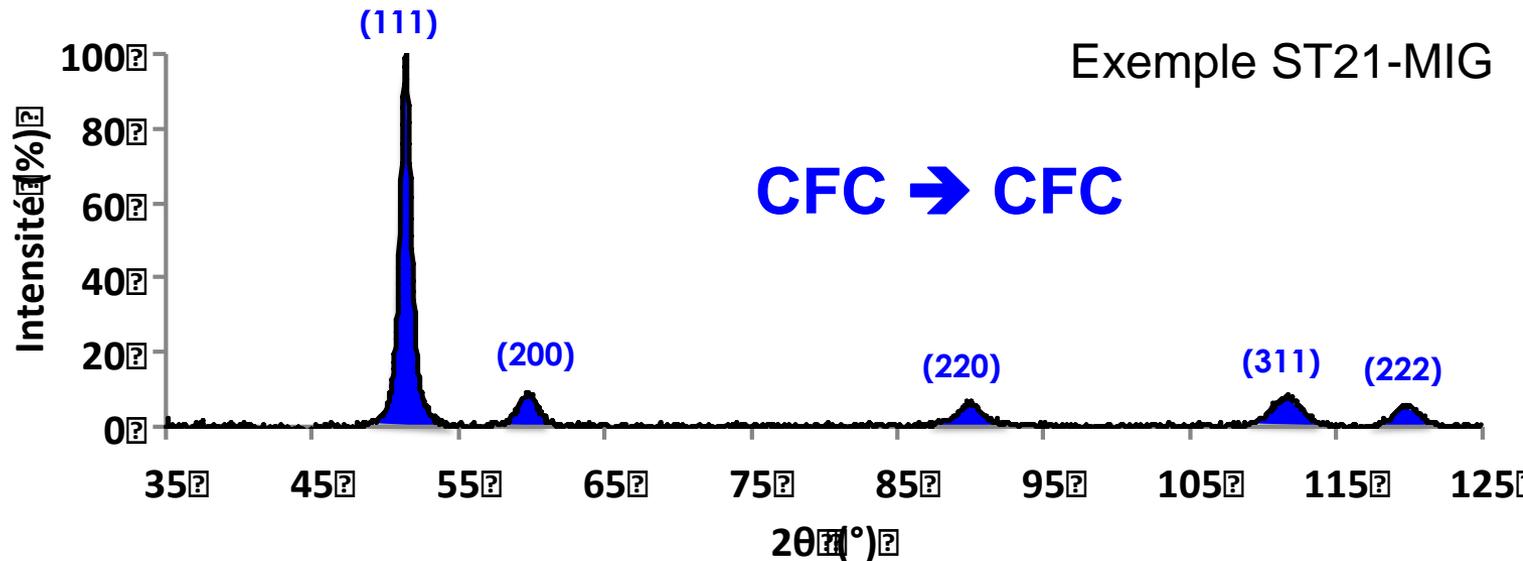
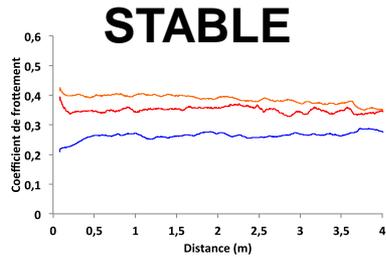
Hardness ↗
Max value $\approx 700\text{HV}_{0,3}$

Evolution du facteur de frottement



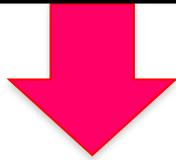
MIG = stable
LASER = decrease and stabilization } $\text{Coef}_{\text{MIG}} > \text{Coef}_{\text{LASER}}$

Structure cristallographique après essai tribologique dans les zones de contact



Comportement au frottement

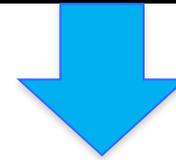
Procédé influence dilution du Fe



MIG

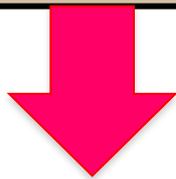
Forte dilution
(30wt%-Fe)

**PTA /
LASER**



Faible dilution
(<1wt%-Fe)

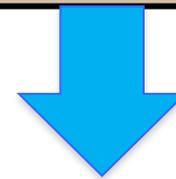
Dilution Fe influence énergie de défaut d'empilement (EDE)
& mécanismes de ϵ_p



EDE ↗

Glissement de dislocations parfaites
Réorientation de grains

Coefficient de frottement ↔



EDE ↘

GDP + Transformation de phase
CFC => HC

Coefficient de frottement ↘

Conclusion

- **Comparaison des 3 types de rechargements**
 - MIG
 - Laser
 - PTA

➔ Métallurgie de soudage différente
- **Rechargements industriels sur matrices aéronautiques**
- **Le laser et le PTA donnent de bons résultats également sous presse industrielle**
- **Baisse significative du coefficient de frottement dans le cas des rechargements PTA et laser**
 - changement de phase CFC/HC
 - En lien direct avec la dilution engendrée par lors du rechargement