Introduction to the monitoring of phase transformation and recrystallization with laser ultrasonics

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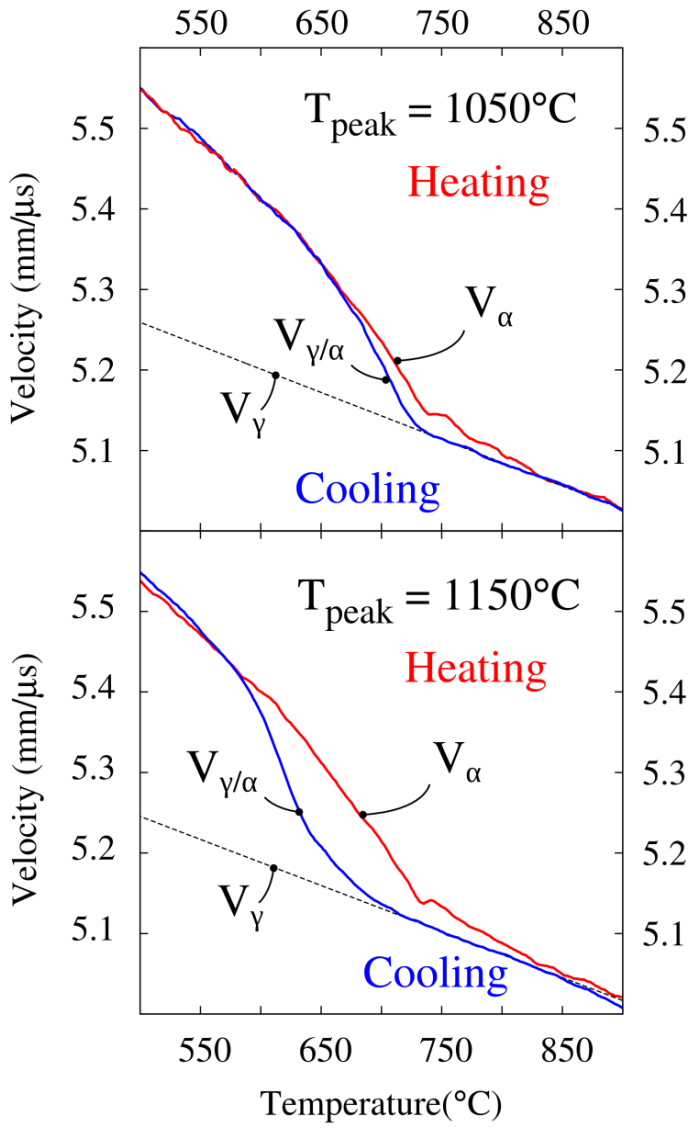
Velocity measurements

- Velocity difference between ferrite and austenite

$$v \cong \sqrt{\frac{\lambda + 2\mu}{\rho}}$$

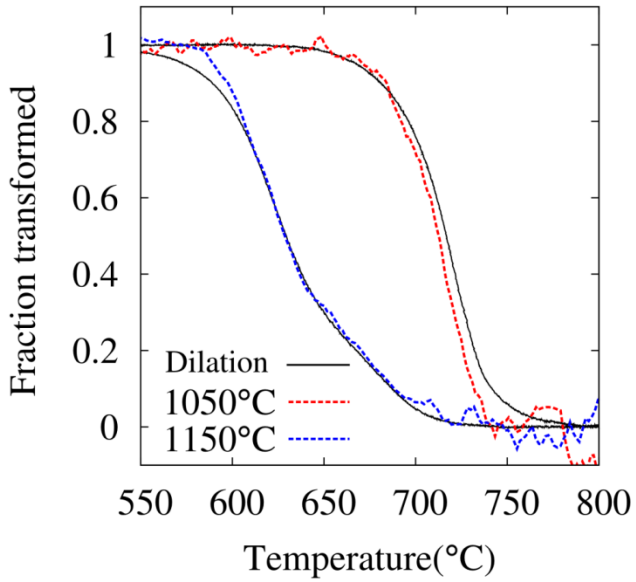
- Application of the lever-rule method on ultrasonic velocity

$$f_\alpha = \frac{v_\gamma - v_{\gamma/\alpha}}{v_\gamma - v_\alpha}$$

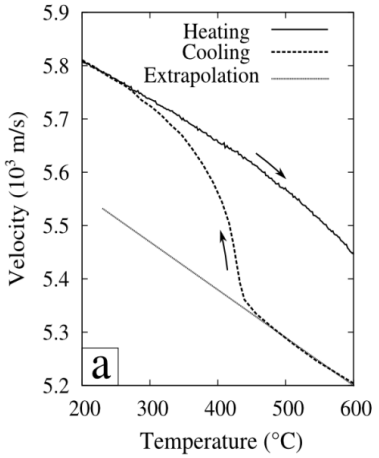


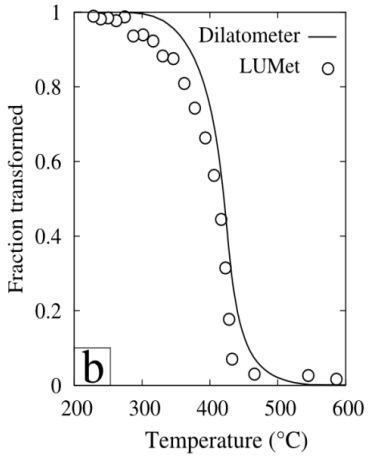
Fraction transformed

Continuous cooling rate 3,10 C/s

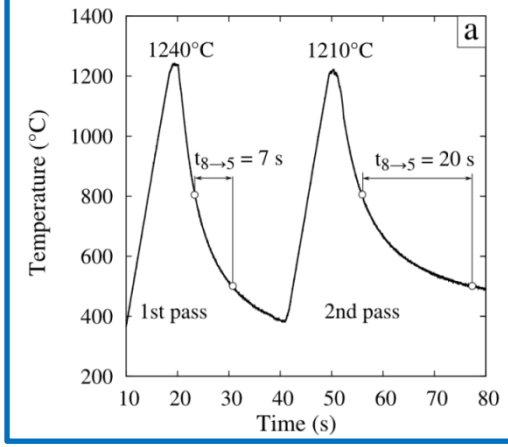


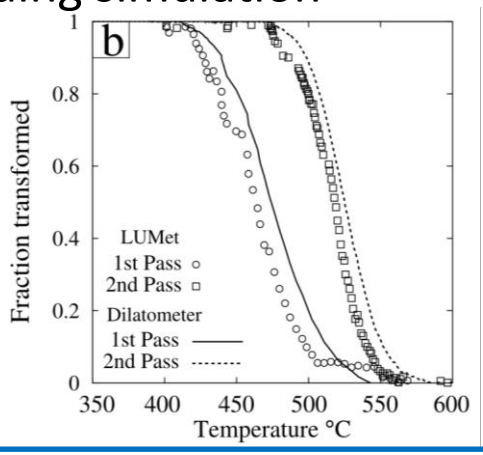
High cooling rate 150C/s





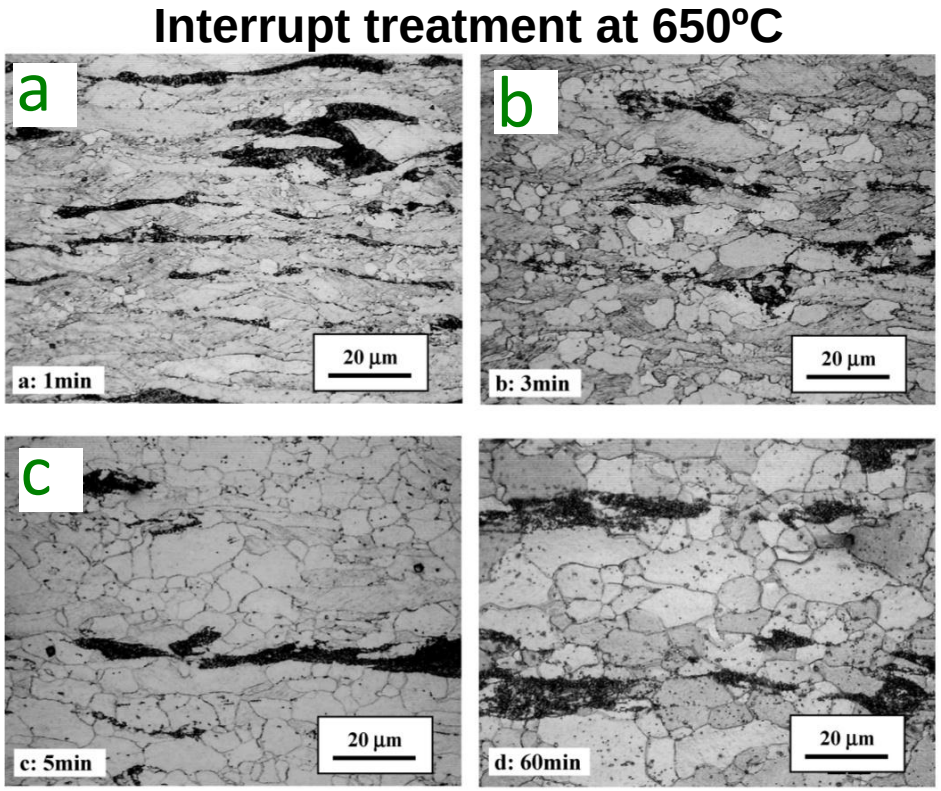
Dual torch welding simulation



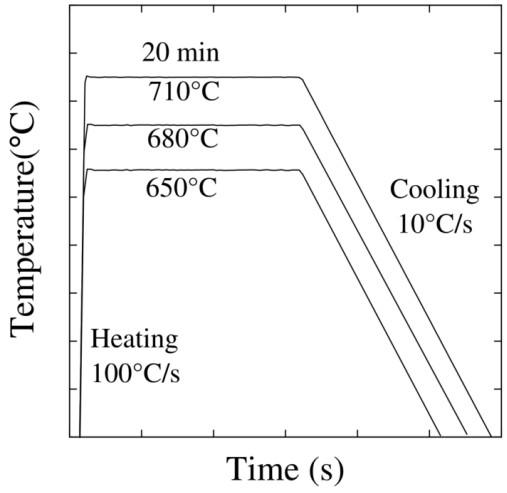


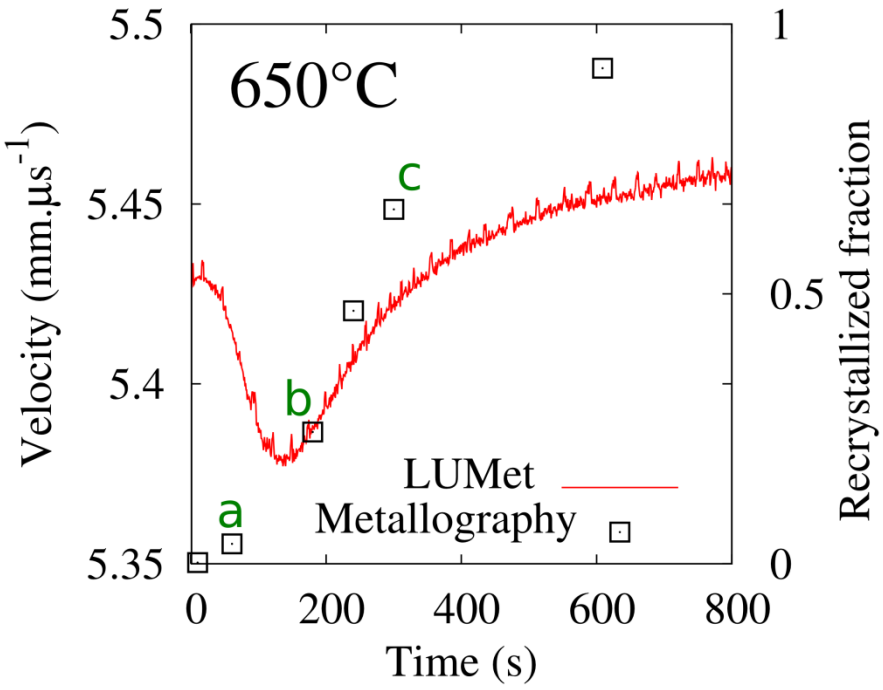
Velocity vs Hardness measurements

- ✓ Dual Phase Steel 55% Cold Rolled

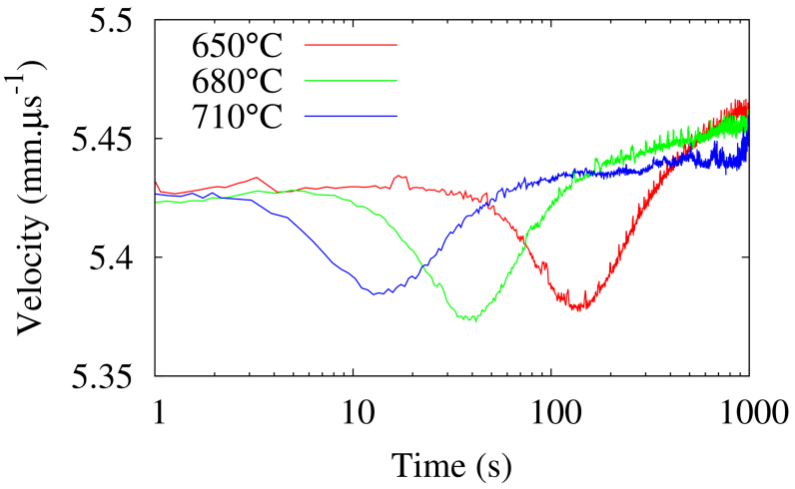


Huang J, Poole W J, Militzer M, Metall. Mater Trans.(2004) 35A, pp3363





Modified lever rule method



Segmentation of the velocity

↓

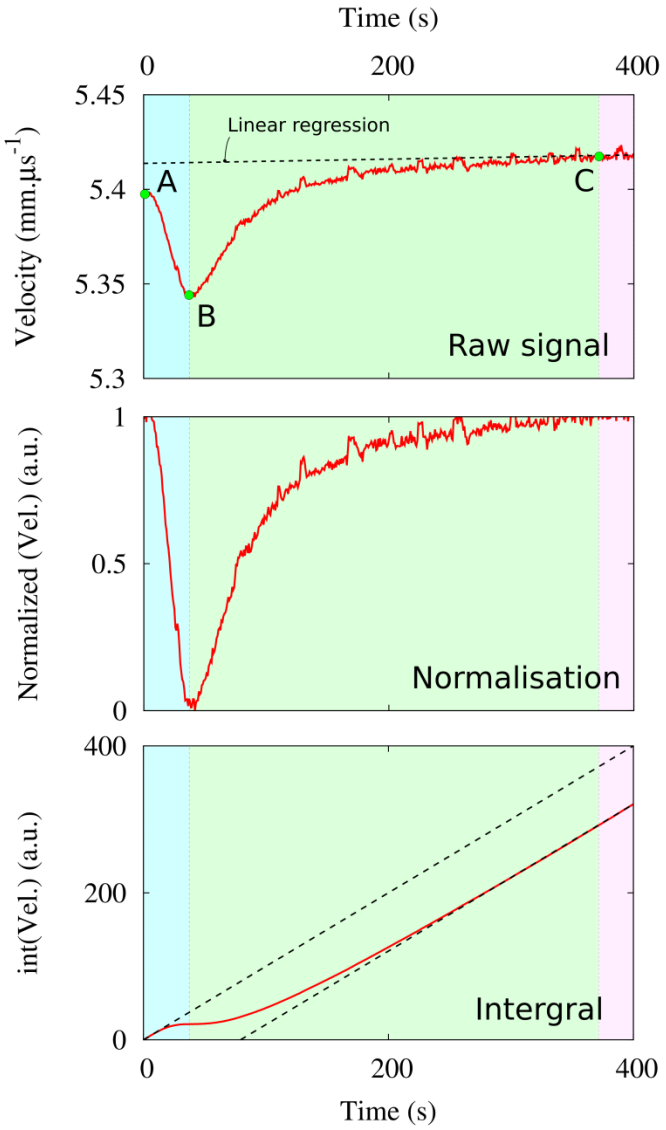
Normalisation of individual segment

↓

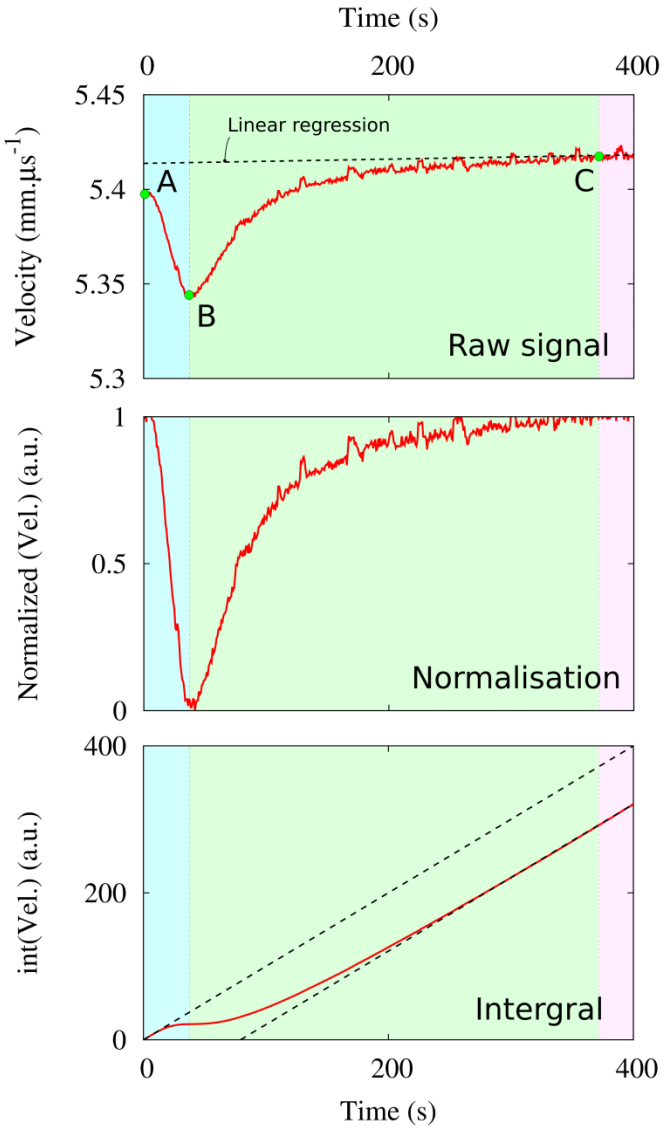
Integration of the normalized signal

↓

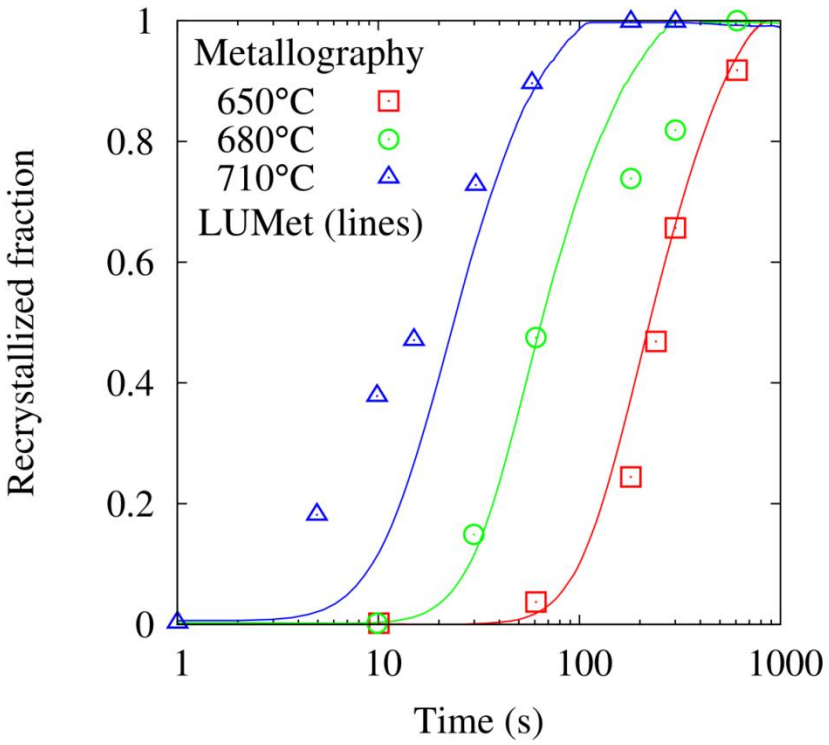
Application of the lever rule



Modified lever rule method

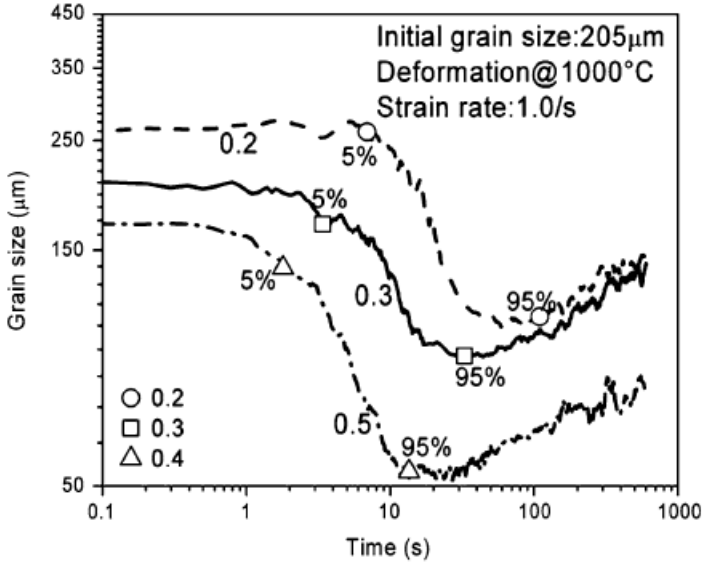


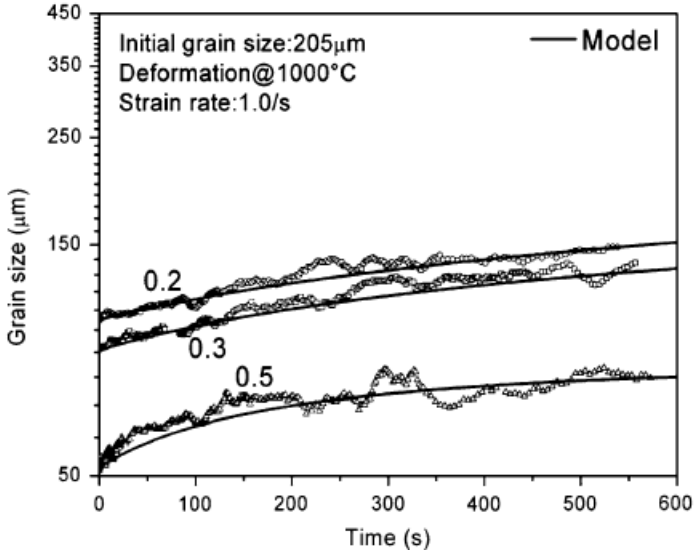
- ✓ Evolution of the recrystallized fraction validated with metallographic observations



Previous work on CP steel

- ✓ Laser Ultrasonics has already shown great potential for the monitoring of austenite recrystallization and grain growth following hot deformation.
- ✓ Sarkar, Moreau, Militzer, Poole, Met. Mater. Trans. (2007) 39A, 897





Important points

- ✓ Phase transformation :
  Velocity difference between parent and product phase

- ✓ Recrystallization :
  Recrystallized fraction from velocity
  Mean grain size from attenuation