Bainitic transformation: a synchrotron experiment…

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An old question…

- What is the carbon content in ferrite right at the beginning of Bainite transformation?

  …a somewhat controversial question…

- Lattice spacing recording and carbon content: We should record the position of the peak and the splitting of the peak over a period of about 2 seconds (the time required for a growing plate tip to traverse a 10 μm beam). Time evolution of the peak is important as well (in order to evaluate the kinetics of carbon content change). The actual time resolution should be of the order of milliseconds.

What is needed?

- Rapid aquisition
- Localised probe
- A pre identified Bragg peak

$\Rightarrow$ Synchrotron in situ experiments

$\Rightarrow$ Two step heat treatments

Alloy

- Alloy selection : We choose an alloy used by Quidort and Brechet (ref. Acta Mat. 49, 2001, pp 4161-4170) containing nickel as an alloying element. (0.5 mass % C, 4.8 mass %Ni).

- This alloy has been extensively studied in terms of macroscopic kinetics, the range of occurence of bainite is well known, and the scales of the microstructure as a function of temperature and holding time is well known .
- The feasability of a two step heat treatment allowing to have sucessively a slow formation of allotriomorph ferrite and the fast growth of a bainitic ferrite has already been established.

Alloy composition

Pergamon

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ISOTHERMAL GROWTH KINETICS OF BAINITE IN 0.5% C STEELS

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Table 1. Chemical composition of the alloys (in 10^{-3} mass%)

Alloy	C	Mn	Ni	Si	Cr	Al
A	478	<1	4870	4	<1	<5
B	490	<1	4870	508	<1	3
C	485	<1	4860	1030	<1	3
D	485	<1	4820	1550	<1	3
E	485	<1	4790	2130	<1	4

Two step heat treatment

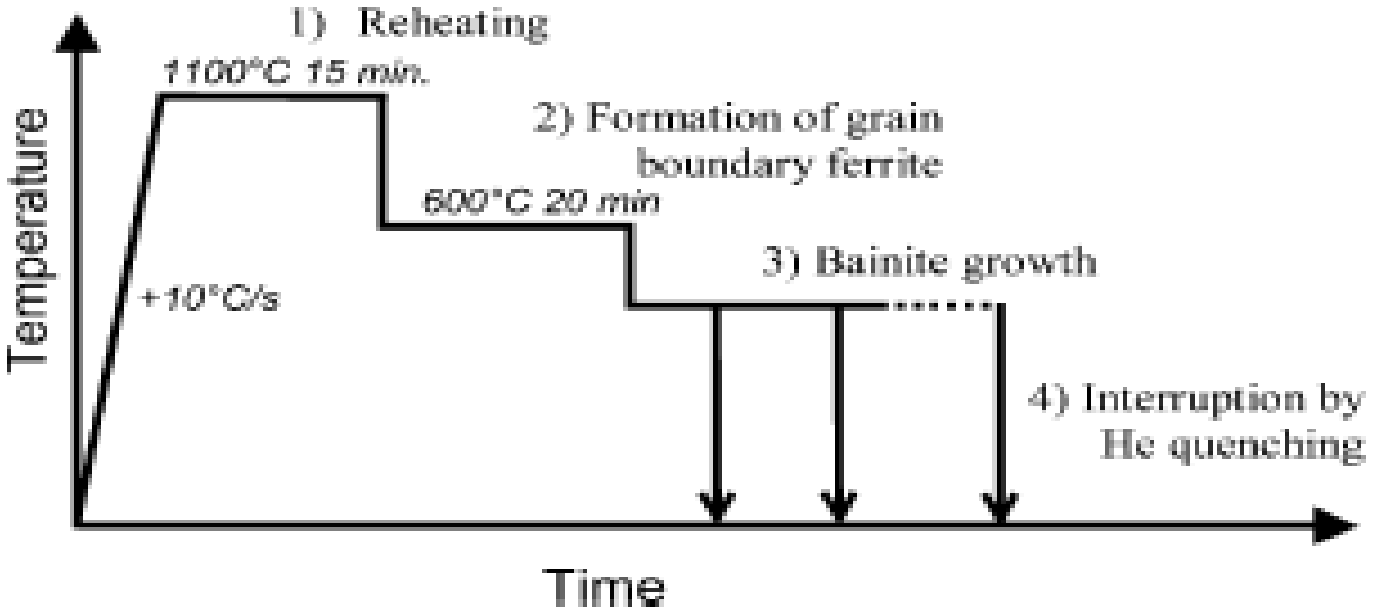

Fig. 1. Schematic diagram of the experimental procedure for determining the lengthening kinetics of laths.

Heat treatments and measurements

- Heat treatment:
- Austenitize for at least five minutes at 1110 C.
- Cool to (10C/sec or less, this rate is not important) to 600 C, and hold for up to 20 min. This will cause the formation of grain boundary ferrite at most austenite grain boundaries.
- When the ferrite appears, use a microfocus (10 μm) beam to establish the orientations of the ferrite and austenite; make sure that this is near Kurdjumov-Sachs.
- Next, rapidly cool (about 10 C/sec.) to 400C; bainite should form and essentially fill the austenite grains in a minute or two. (Lengthening rate is about 5 μm/sec.)

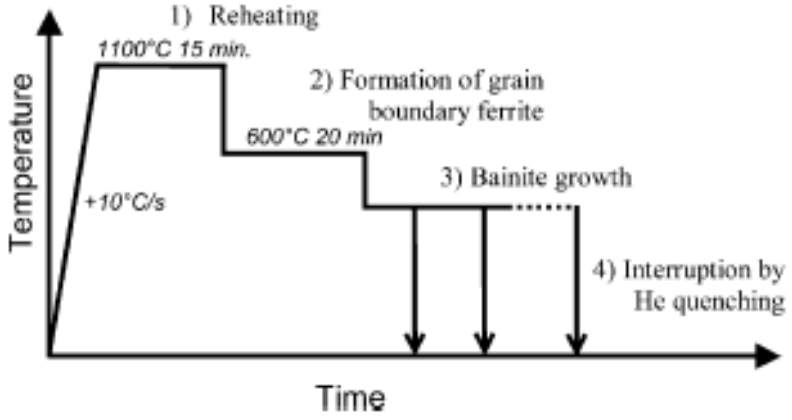

Fig. 1. Schematic diagram of the experimental procedure for determining the lengthening kinetics of laths.

Some reasons to hope…

- Beam size: 10 micron is no problem actually (even 1 micron can be achieved on some beam lines)
- However, depending if you work in transmission or reflection geometry, you have to take into account the foot print on the sample.
- Furnace: there are in the lab several furnaces. Atmosphere is not a problem, we work under secondary vacuum
- The problem is probably the cooling rate: As far as I remember, our cooling rate is rather of the order 5C/s, but this need to be checked.
- Time scale: 1 ms time scale resolution is probably difficult to achieve. Again some test on a beam line (ID1 for instance) should be made.

Preliminary experiment in Grenoble ESRF, june/july 2008