EUROPEAN SYNCHROTRON RADIATION FACILITY

INSTALLATION EUROPEENNE DE RAYONNEMENT SYNCHROTRON

Experiment Report Form

	Experiment title: **In-situ study of the phase transformation kinetics and strain evolution during welding using novel Low Temperature Transformation filler materials by means of EDXRD**	**Experiment number**: MA-847
Beamline: ID15A	**Date of experiment**: from: 21.10.2009 to: 27.10.2009	**Date of report**:
Shifts: 18	**Local contact(s)**: Dr. Thomas Buslaps / Dr. Veijo Honkimäki	*Received at ESRF:*

Names and affiliations of applicants (* indicates experimentalists):

Gibmeier, Jens * - Institute for Materials Science and Engineering I, Karlsruhe Institute of Technology (KIT), Kaisersrasse 12, D-76131 Karlsruhe, Germany

Altenkirch, Jens * - Institute for Materials Science and Engineering I, Karlsruhe Institute of Technology (KIT), Kaisersrasse 12, D-76131 Karlsruhe, Germany

Kromm, Arne * - Federal Institute for Material Wanner, Alexander - Institute for Materials Science and Engineering I, Karlsruhe Institute of Technology (KIT), Kaisersrasse 12, D-76131 Karlsruhe, Germany

Report:

Introduction:

The aim of this experiment was to investigate the effect of different alloying compositions (variation in Ni-content between 8-12 wt%) of three novel Low Temperature Transformation (LTT)-alloys on the phase transformation kinetics and to characterise the arising phase-specific residual strain and stress under real welding conditions using a self designed on-line welding rig and the EDXRD setup on ID15A. For comparison ex-situ measurements on welded specimens were performed to show the stress mitigation effect of the different filler materials in the final weld.

Setup:

We used the ID15A EDXRD set-up with the two Ge-detectors set to approximately 2Θ = 6° in both, the horizontal and vertical scattering directions. To allow for high counting rates XIA-read-out electronics were used allowing for continuous counting at rates higher than one Hz. For on-line welding the base plate with the LTT material welded onto one edge was positioned as depicted in Figure 1a (Note, for clarity the illustration displays only one detector). In this set-up the horizontally offset detector measured the weld longitudinal direction, while the vertically offset detector determined the behaviour in the weld transverse direction simultaneously. During the welding cycle the gauge volume was positioned stationary within the weld-line while the weld tool traversed along the LTT bead. Measurements were taken as a function of time and temperature at different lateral distances from the weld-line. For ex-situ measurements three 15mm thick sample plates (one for each LTT-alloy) were positioned with the weld-line vertical and perpendicular to the primary beam. Comb samples were used for reference measurements in order to obtain the stress free lattice parameter distribution. A biaxial stress field was assumed for stress calculation.

Results:

Figure 1b displays a density plot (intensity and energy vs. time and temperature) for an LTT alloy with 8wt% Ni at 5mm from the weld-line during the welding cycle. The temperature distribution as obtained at the material surface using a thermal imaging camera is superimposed and allows for determination of the transformation temperatures. While the α-phase dissolves into austenite at app. 390°C, the martensite transformation for this material starts at. 241°C (based on α-ferrite/martensite *200* and *211* peaks).

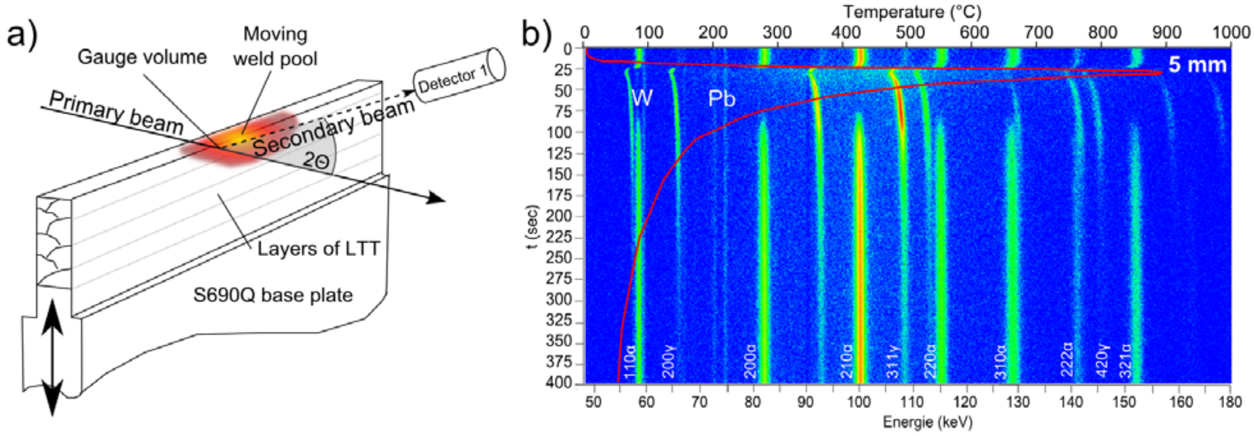

Figure 1: Schematic illustration of the online welding setup (a) and a density plot of the intensity vs energy as a function of time and temperature as obtained during online welding the 8wt% Ni specimen shows the phase transformations (b).

Upon further cooling the martensite transformation completed below 50°C. We monitored the phase transformations at 10 distances from the weld surface at various counting times ranging from 3 to 0.5sec. On the one hand these measurements proved the applicability of the set-up for future in-situ welding experiments. Further, the high counting rates enabled precise determination of the transformation temperatures and as such allows for improved understanding of the transformation kinetics. Further data analysis of the strain evolution during welding in the two perpendicular directions as monitored in this experiment, will allow gaining insight into the strain behaviour during the phase transformation and as such allows quantifying the residual stress development upon cooling as a function of the LTT composition.

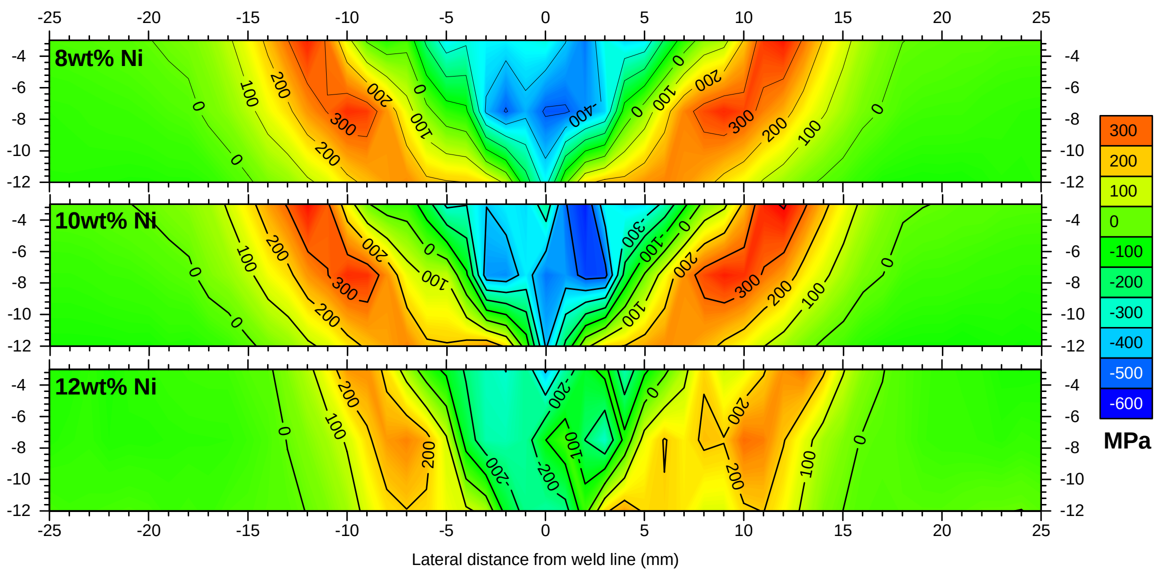

Figure 2: Longitudinal residual stress distribution in 15mm thick welds joined using LTT-alloys.

While the 8 and 10wt% Ni LTT-alloy welds display significant longitudinal compressive stresses in the weld line, which are balanced by tensile stresses in the heat affected zone, the 12wt% Ni weld displays considerably less compressive and tensile stresses as shown in Figure 2. Presumably, the high amount of retained austenite in the 12wt% Ni sample allows for less compressive stress to build up and consequently less balancing tensile stress.