Crystallographic Texture of Induction–welded and Heat–treated Pipeline Steel

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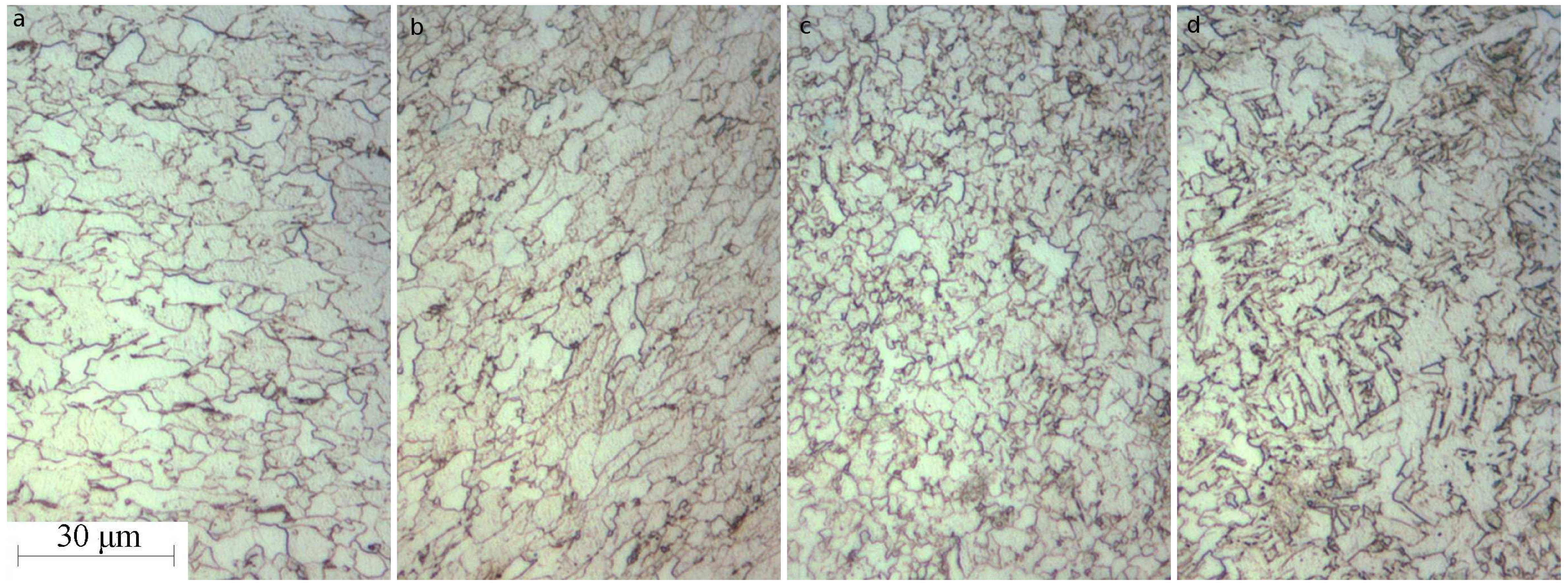
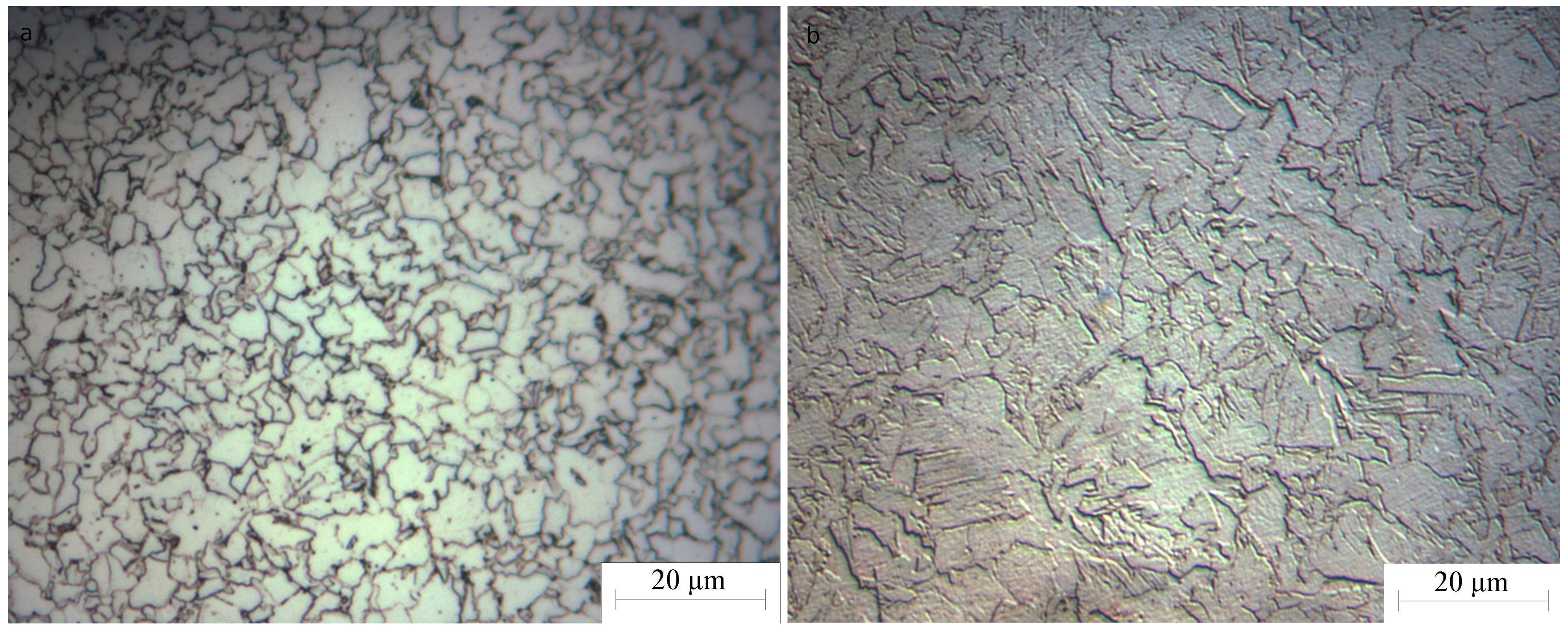
Steel pipes are produced by induction seam–welding followed by induction–assisted heat treatment. The microstructure and distribution of crystal orientations have been studied and related to the mechanical properties of the welded regions. The welding process leads to a microstructure, a simple observation of which can not explain the observed variations in toughness in the vicinity of the welding joint, because the crystallographic grain size, which represents the scale of similarly oriented adjacent grains, can be coarser than the ordinary grain size [1, 2]. Furthermore, heating the affected zone into the austenite phase field followed by cooling does not completely eliminate the coarse regions of similarly oriented grains.

Microstructural Characterisation

On the as–welded stage, the joint consists of four zones: a. base metal, b. thermomechanically affected zone, c. heat–affected zone and d. fusion line (FL).



After post–welding heat–treatment, in the same scale of area, only two zones can be differentiated: a. the area affected by the heat–treatment and b. the vestige of the FL.



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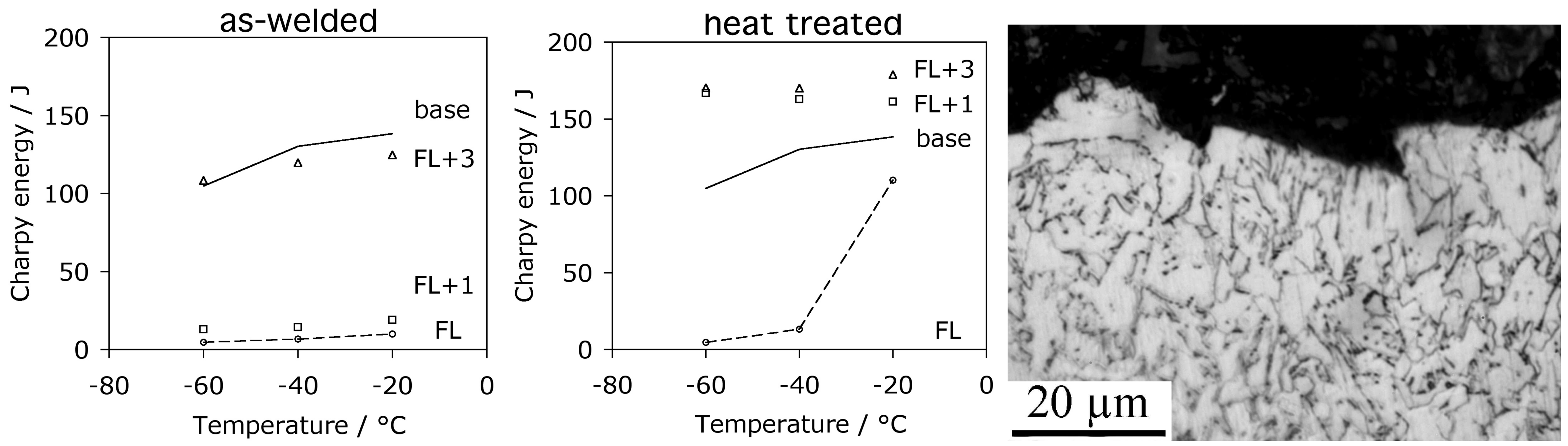
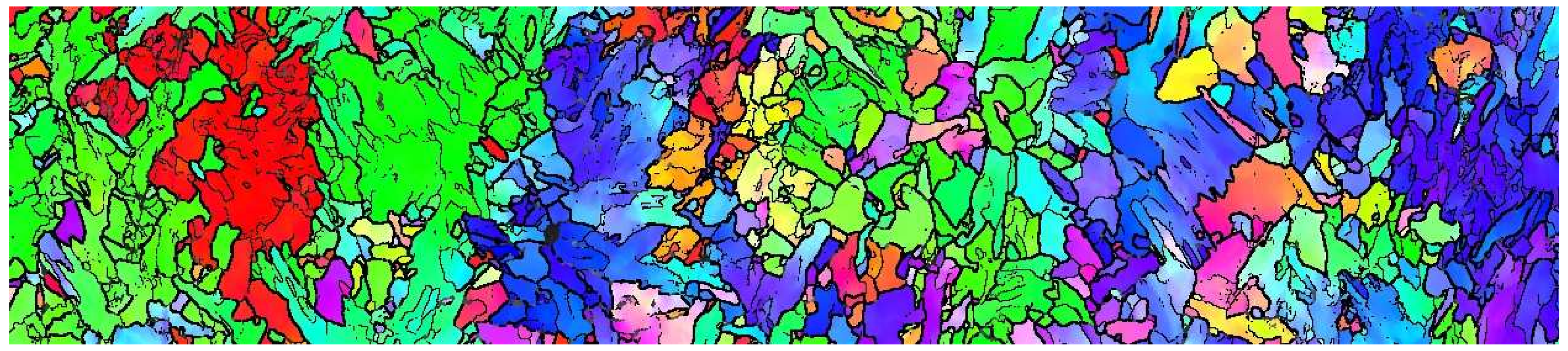
Charpy Impact Data

The Charpy energy of the sample after heat–treatment was significantly higher than the as–welded sample when the V–notches were located 1 or 3 mm away from FL. However, when the V–notch was located on FL, the improvement in toughness from the heat treatment was not so obvious with no enhancement noted for the test temperature of $-40\,^{\circ}\mathrm{C}$. Under this condition, the facets of the fracture surface are in the size of $0.2\ \mu\mathrm{m}$.

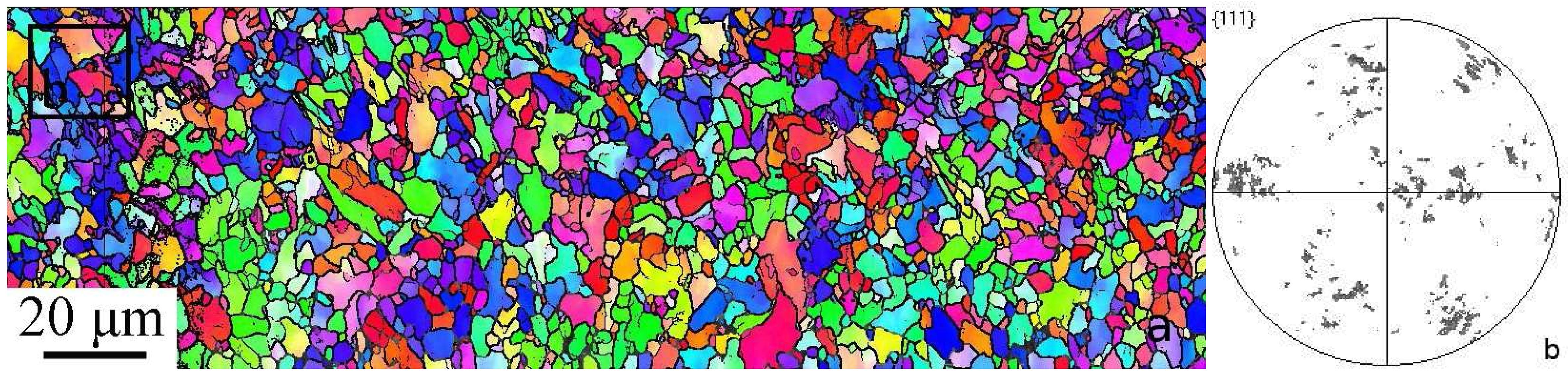


Crystallographic Characterisation

The crystallographic grain size is very coarse at the as–welded FL. In the orientation images presented below, blue, green and red colours represent the $\{111\}$, $\{110\}$, and $\{001\}$, pole respectively, normal to the plane of the image. This observation was confirmed by looking at the detailed pole figures which are not presented here for brevity.



The coarse crystallographic grain size persisted after heat–treatment. The accompanying stereogram shows clusters of grains which are almost identically oriented over regions coarser than $0.2\ \mu\mathrm{m}$. These results explain the persistence of low toughness in this region after heat–treatment.



The question then arises as to why the austenite texture present just after welding does not vanish during the reaustenisation that occurs in the induction post–welding heat–treatment. There is published work indicating the existence of an austenite memory effect [3] during rapid reaustenisation experiments. An investigation of this will form the basis of future work.

References

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