Characterisation of nanostructured steel alloys for fission and fusion applications

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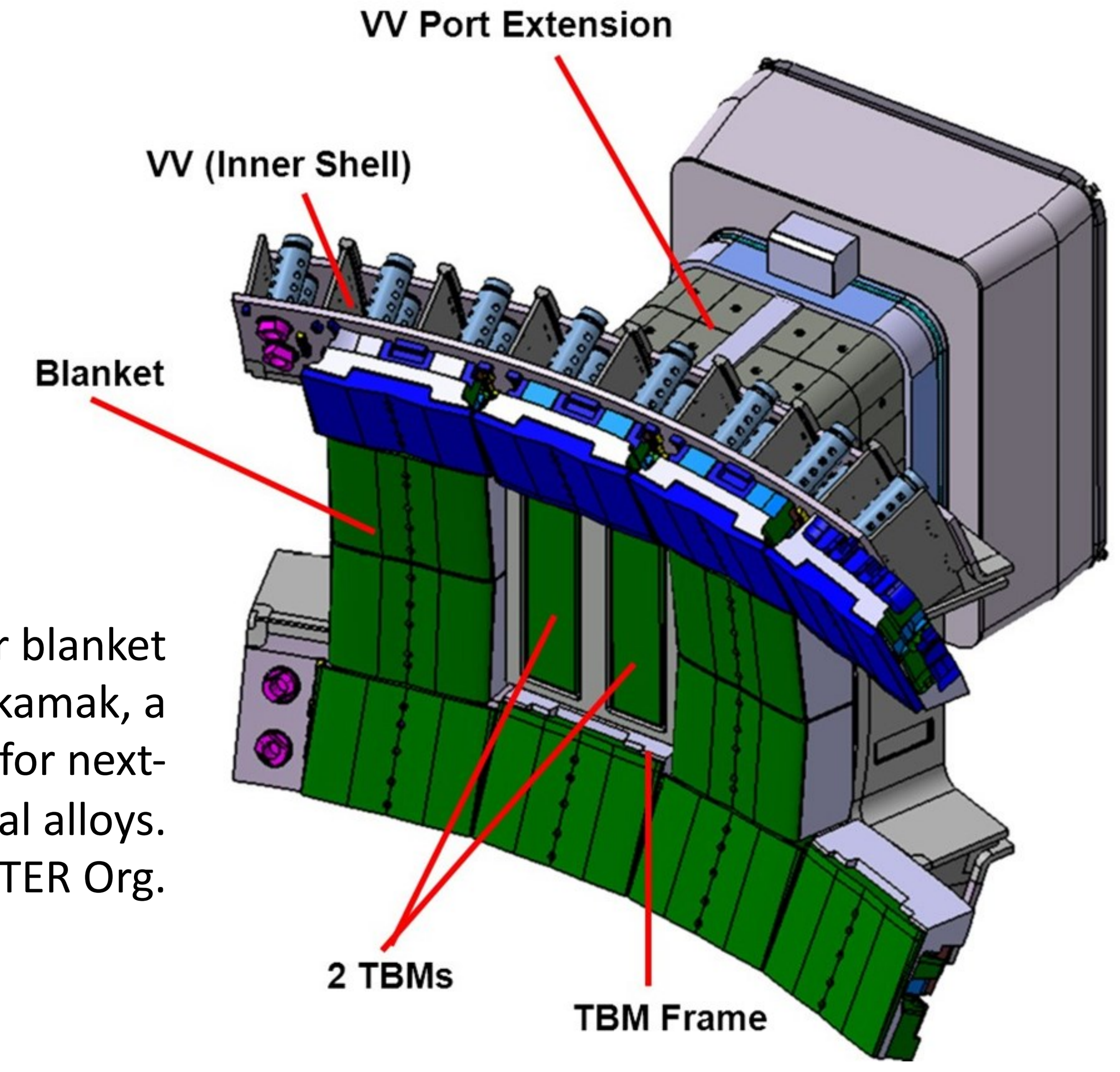
1. Introduction & Motivation

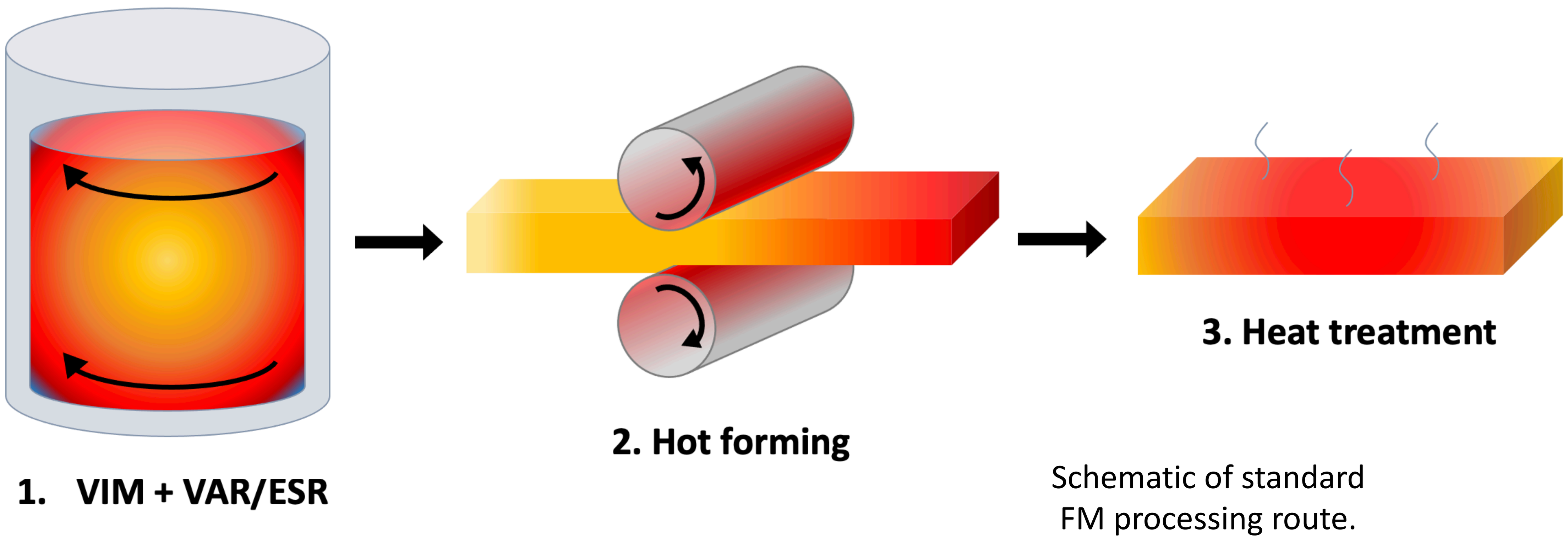
Castable Nanostructured Alloys (CNAs) are a next-generation **ferritic/martensitic** alloy featuring a high fraction (~2.5 vol. %) of ultrafine MX (M = Ta, Ti, V; X = C, N) nanoprecipitates [1] to impart superior creep and radiation properties over existing FM alloys up to 650 °C [2]. CNAs retain an **ease of manufacture** compared to rival oxide-dispersion strengthened (ODS) steels, making them promising candidates for **structural applications** in near-term **Gen IV fission** reactors and prototype **magnetic confinement fusion** devices [1,3].



Location of the breeder blanket within the ITER tokamak, a foreseen role for next-generation structural alloys. © ITER Org.

2. Materials & Processing

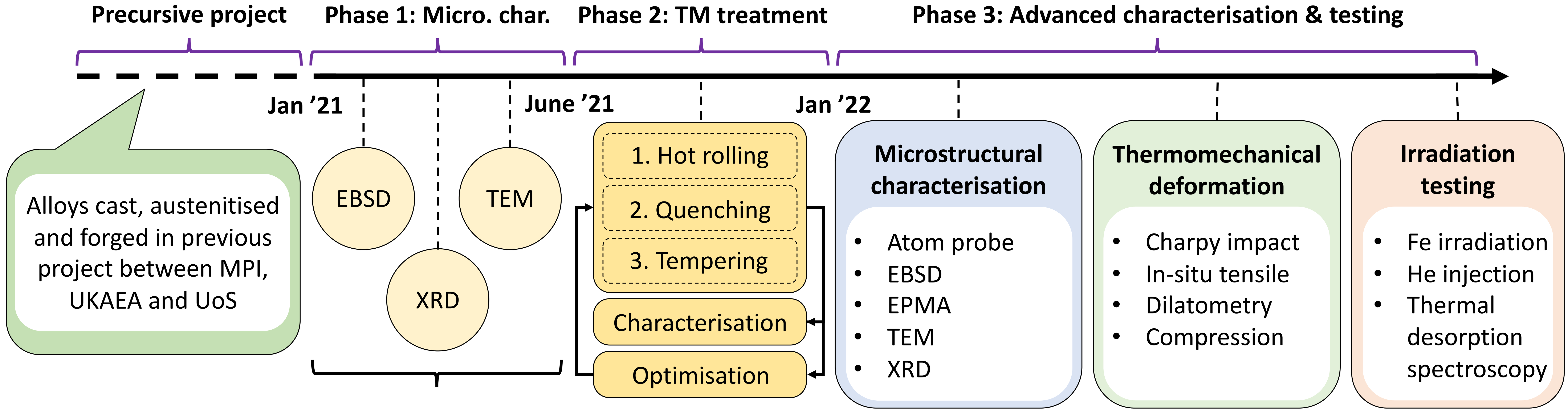
- Two 'low-activation' compositions based on **commercial P91 steel**.
- Both feature **high N %** to **promote nitride precipitation**.



Schematic of standard FM processing route.

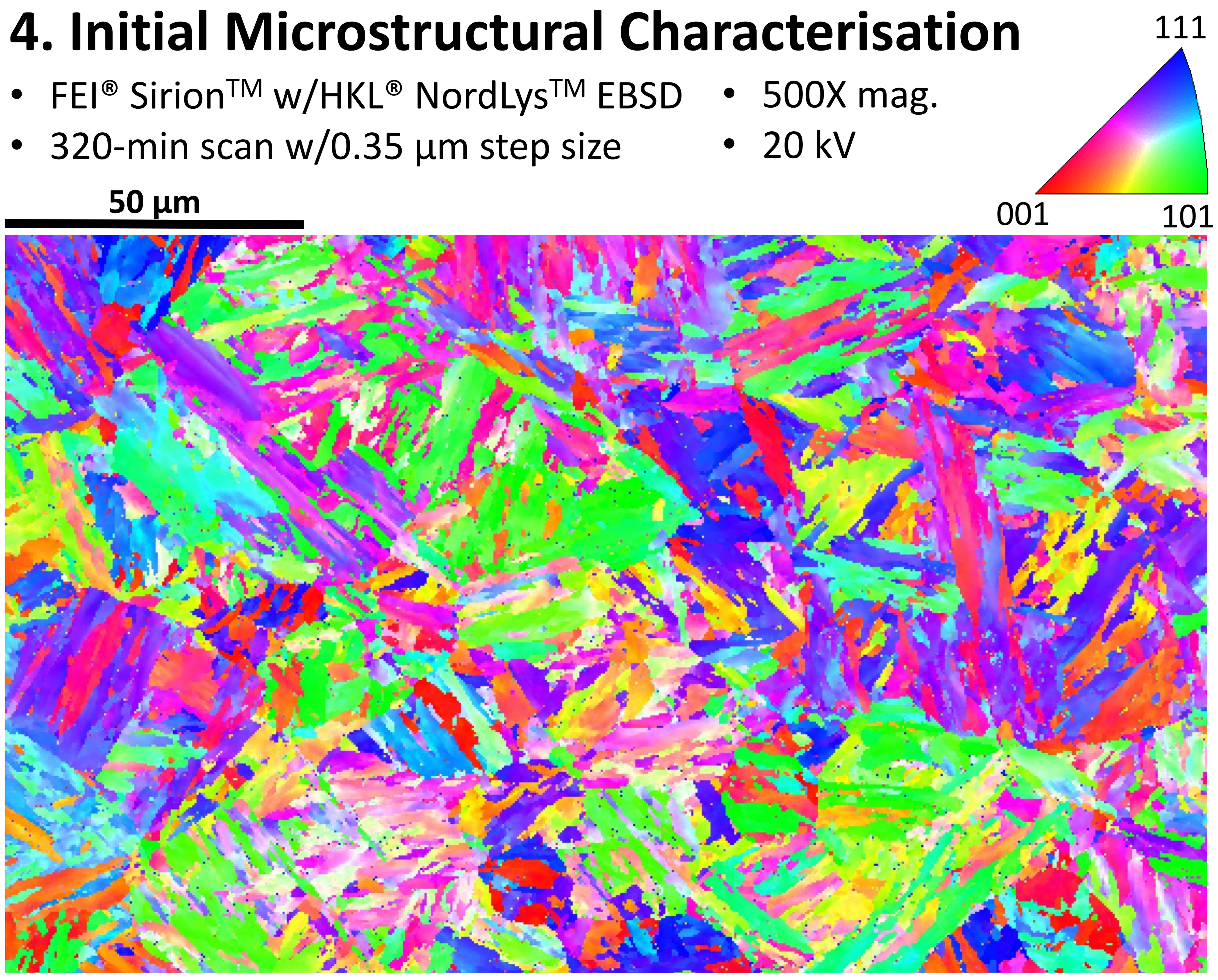
1. 100-kg casts produced via **VIM** (Materials Processing Institute).
2. **2-hr austenitisation** at **1100 °C**, &
3. Primary **forging** (4:1 ratio; 50 cwt.) into 90 mm² bars (Special Quality Alloys).
4. **Air cool** to ambient.

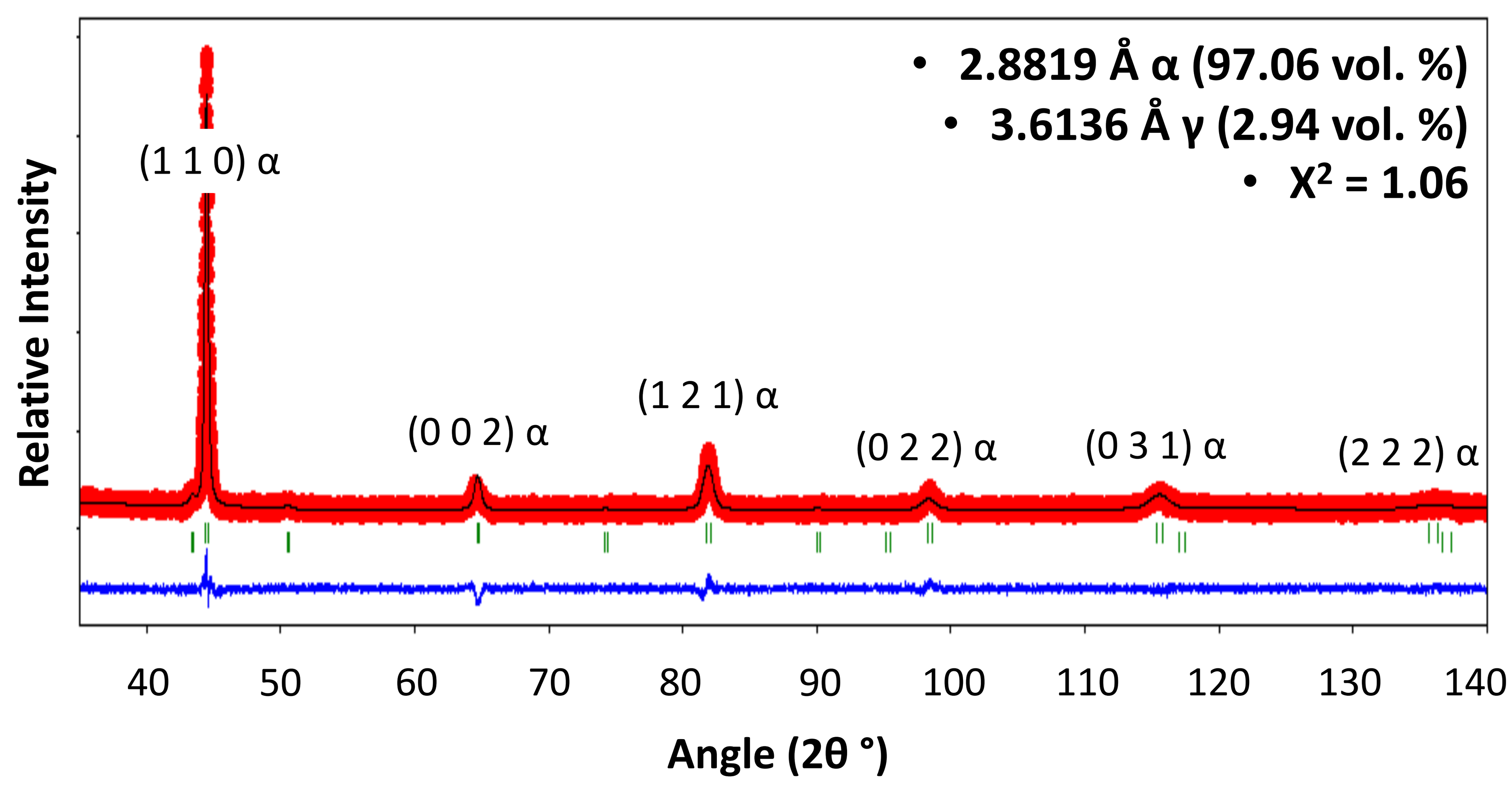
3. Experimental Overview



4. Initial Microstructural Characterisation

- FEI® Sirion™ w/HKL® NordLys™ EBSD
- 320-min scan w/0.35 μm step size
- 500X mag.
- 20 kV





Next Steps

- Complete as-received **microstructure characterisation** (TEM).
- Design & perform **thermomechanical processing** regimes.
- Characterise TM processed microstructures & **optimise TMP** parameters to produce high MX densities.

References

1. Tan et al. (2016). DOI: *10.1016/j.jnucmat.2016.05.037*.
2. Tan et al. (2014). DOI: *10.1016/j.actamat.2014.03.015*.
3. Zinkle et al. (2017). DOI: *10.1088/1741-4326/57/9/092005*.

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