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Emergence & Progression of Abnormal Grain Growth in Minimally Strained Nickel-200

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It is widely understood that the mechanical properties of metals are heavily influenced by grain size and grain boundary character. Grain boundary engineering (GBE) is a frequently utilized approach to control the distribution, arrangement and identity of grain boundary networks. However, prior grain-boundary engineering studies have shown that it is a challenge to reliably control grain size in minimally strained metals [1-3]. Furthermore, the phenomena of abnormal grain growth (AGG) and its contributing factors are still a subject of much debate in both GBE and non-GBE metals [4-6].

In this study, orientation imaging microscopy (OIM) is employed to examine the emergence and progression of abnormal grain growth in a low-strained, commercially pure, polycrystalline Nickel. Experiments encompassed a variety of thermal cycles and varying amounts of initial cold-work. The onset of abnormal grain growth was observed to occur at specific pairings of strain and temperature following cyclic annealing throughout the low strain regime where reductions ranged from $0 \leq \varepsilon \leq 9\%$. Furthermore, distributions and cumulative area fractions of grain size quantitatively confirmed the correlation between onset temperature and strain for AGG. To this end, an empirical relationship describing the impact of thermal exposure and initial strain content on the onset of AGG in Ni-200 is provided.

For low coincidence site lattice (CSL) boundaries; Σ3, Σ9, and Σ27, local maxima were observed to occur at or immediately following the onset of AGG. Within the range of these emergence events, the inherent crystallographic segmentation of grain orientations is leveraged with image processing to quantify a growth rate for abnormal grains. This growth rate is also shown to be a function of thermal cycle and initial strain content and is reported across the explored range of low strain. For a pictorial example of the AGG identification, See Figure 1.

Based on the experimental observations, suggestions for the mechanisms at play in these instances of abnormal grain growth are offered and discussed.

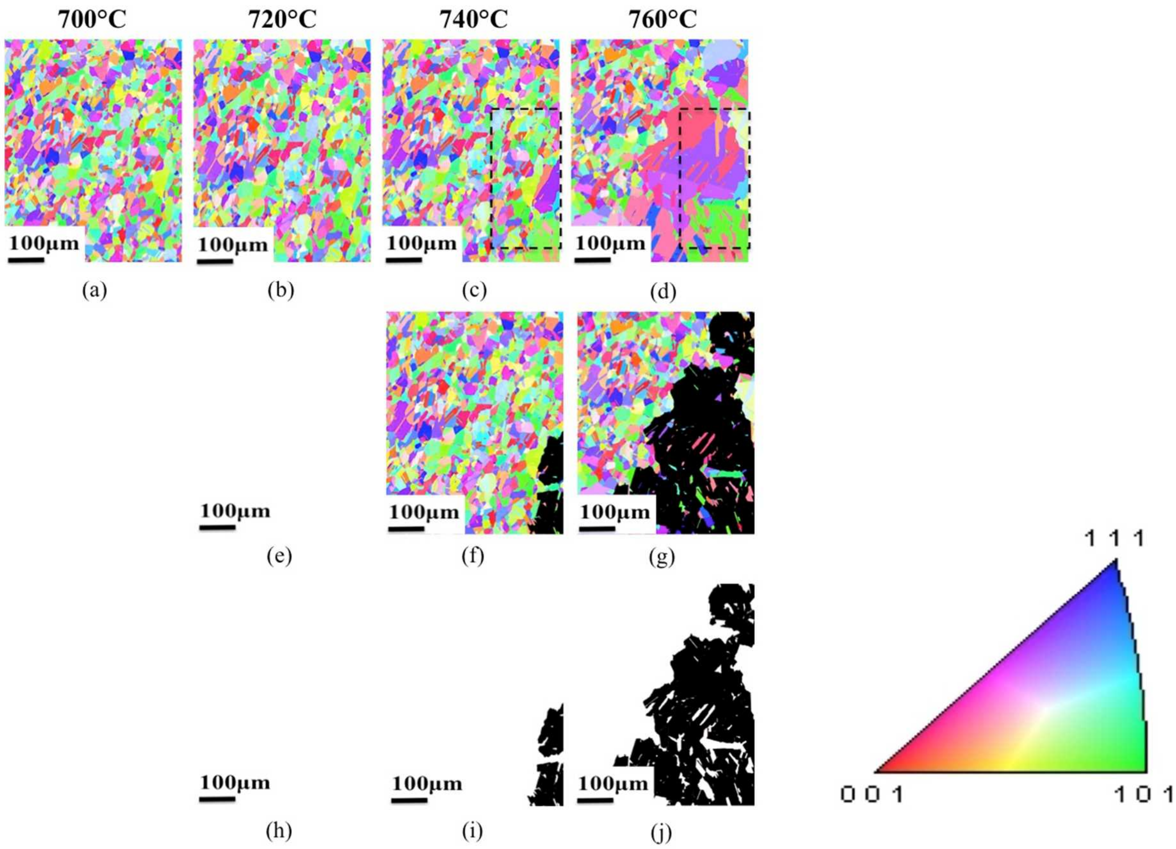

Fig. 1 (a-d) Orientation imaging microscopy progression maps for 3% induced strain following annealing treatments ranging from 700 to 760°C; (e-h) AGG region observed in black

References

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