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The goal of this project is to develop a procedure for picral-free prior austenite grain boundary etching.

Prior austenite grain size (PAGS) measurements are frequently challenging due to weak etching response to reveal the boundaries. Further, some of the etchants contain chemicals that could be explosive under certain circumstances; notably dry/crystallized picric acid is explosive and Nital etchant preparation needs to be done carefully to avoid strong heat evolution that could lead to boiling and explosion. These environmental, health and safety (EHS) hazards have led some laboratories to ban certain of these etching substances.

The present approach investigates low-temperature-melting metals to wet austenite grain boundaries and assesses whether liquid metal etching can be used instead of organic chemicals etching. Liquid metal embrittlement is known to occur for steel substrates in contact with, e.g., liquid zinc where wetting, and attack of PAG predominantly over the grain interiors locally weakens the grain boundary strength and cohesion. The wetting mechanism will be explored here to evaluate whether it can be employed toward etching and reveal the boundaries for PAGS measurements.

The project scope involves identification of metals and alloys with a low melting temperature (e.g., melt on a hot plate) that have a good EHS profile, e.g., are not toxic, non-hazardous to dispose of, result in effective wetting with carbon steels, show preferred wetting of prior austenite grain boundaries over, e.g., lath boundaries, etc. Potential candidates to include tin, gallium, lithium, bismuth and their alloys are being assessed. Various wetting and (back) polishing iterations are being investigated in addition to a variety of steel grades in particular with very low residual contents (notably phosphor which sometimes is intentionally added to laboratory heats to assist in PAG etching). Light optical metallography (LOM) is being employed to assess etching response effectiveness from the liquid metal wetting. Energy-dispersive spectroscopy (EDS) line scanning will be pursued to image and determine the PAG boundary on the etched sample surface. ✦