The Art of Grain Structure: Recognizing Shapes and Patterns in Materials

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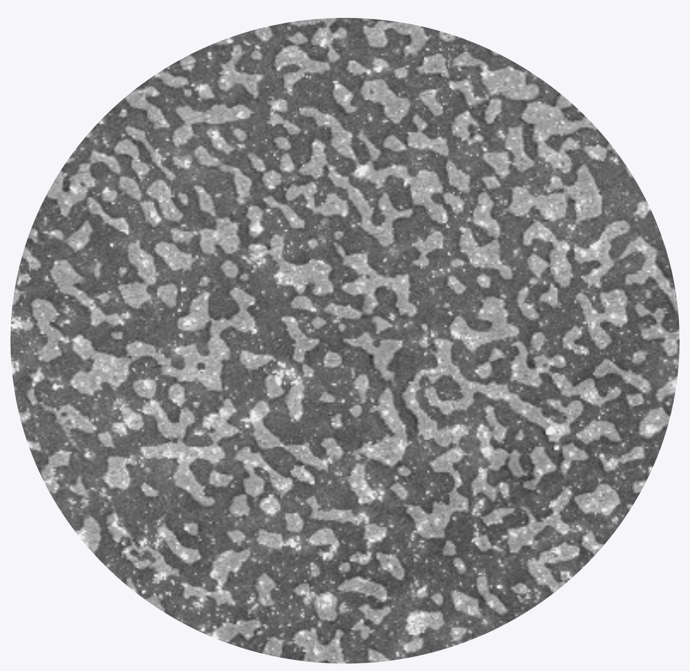
INTRODUCTION

- 18 teams investigated the random formation of grain structures in various stock samples, using multiple preparation methods. The focus was on analyzing microstructural features and discovering artistic patterns within the naturally occurring grain formations.
- A deep understanding of grain theory and microstructural analysis. This experience led to a new appreciation for the random grain structures found in materials we encounter daily, fulfilling the objective of educating on how these structures form and influence

RESEARCH QUESTION

How do the random formation of grain structures in various metals influence both their material properties and the emergence of artistic patterns, and how can these conditions be effectively analyzed using microstructural techniques?



Expected 20wt%Sn, 80wt%Pb Microstructure

Expected Gray Cast Iron Microstructure

EQUIPMENT & MATERIALS

- Buehler PlanarMet 300 Planar Grinder-Polisher
- Buehler SimpliMet 4000 Hot Mounting Press Machine
- AmScope Microscope
- Phenolic Resin Powder
- Grinding Paper and Polishing Medium
- Wet Etch Hood with Nital, Water, IPA and Air Drying
- Stock samples of 1018, 1045, and 1080 steel, ductile and gray cast iron, and lead-tin alloys

FINDINGS:

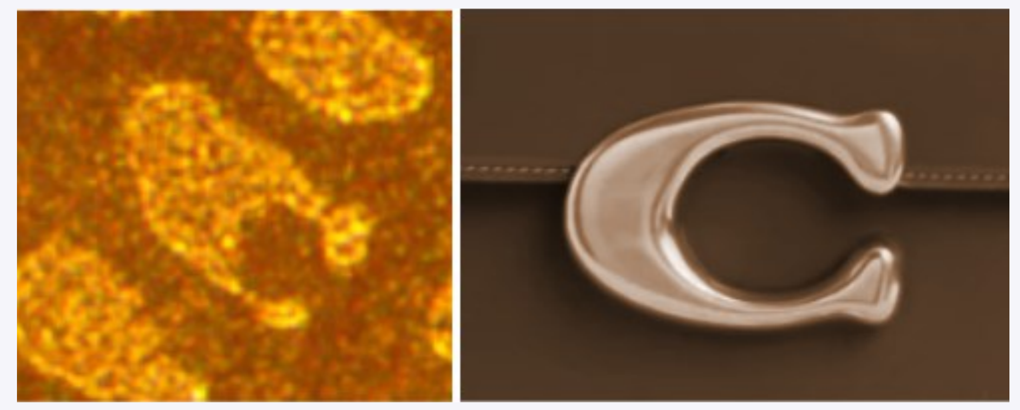


Figure 1: 20wt%Sn, 80wt%Pb — Coach Logo

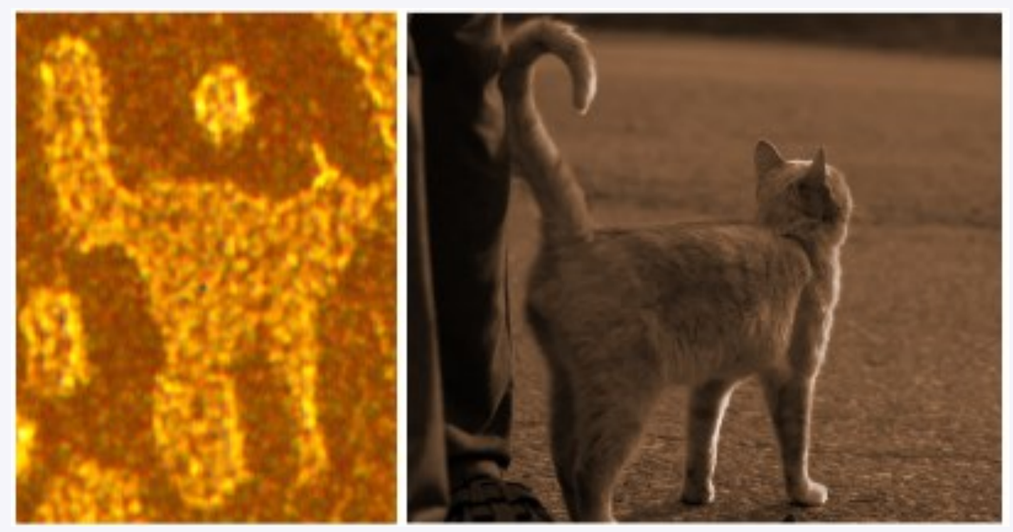


Figure 2: 20wt%Sn, 80wt%Pb — Cat

Figure 3: Gray Cast Iron — Snoopy

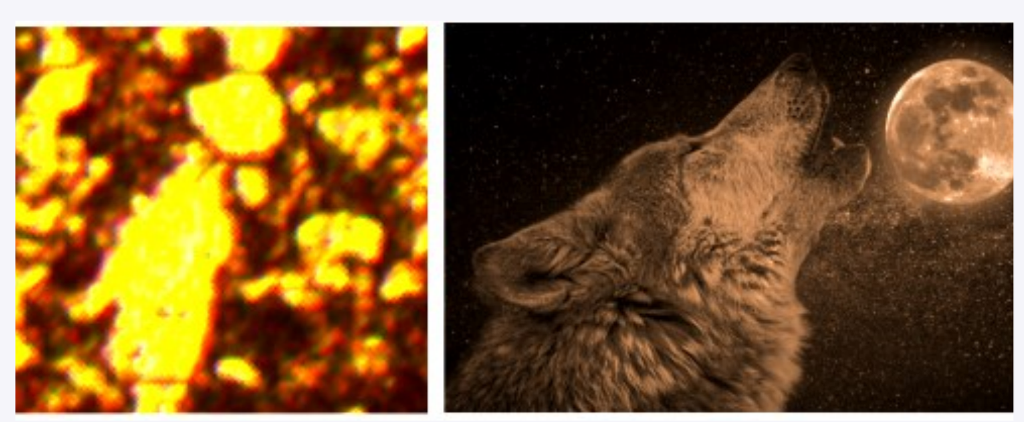


Figure 4: 1045 Steel (annealed) — Howling Wolf

Figure 5: 20wt%Sn, 80wt%Pb — Pringle Chip

METHODS

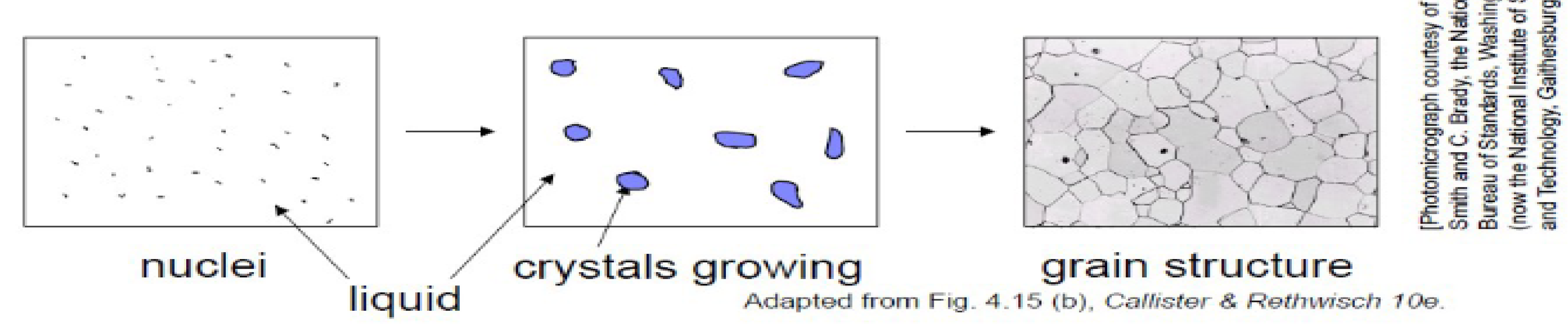
Grinding/Polishing Process:

- Grit size is gradually increased from 80 to 600 grit for a smooth surface under a constant load of 12 pounds, while water is applied throughout to prevent heat and material deformation.
- Polished with a 1.0 µm polishing pad and 1.0 µm alumina, then refined with a 0.5 µm polishing pad and 0.05 µm alumina suspension for a mirror-like finish.

Etching: Samples are etched for 10 seconds using an appropriate etchant, then rinsed in deionized (DI) water and air-dried to reveal grain structures.

Microscopic Examination: Samples examined under a microscope at magnifications from 50x-200x.

GRAIN STRUCTURE FORMATION



REASONING

- Thermomechanical processes like heat exposure and mechanical deformation shape microstructures by affecting grain morphology, phase distribution, and defects. In annealed 1045 steel, heating promotes grain growth and reduces stresses, while localized cooling can cause irregularities. Mechanical deformation, such as in cold-working steels, leads to elongated grains along the deformation axis. In PbSn alloys, tin concentration variations and cooling rates determine the phase structure, with rapid cooling creating finer phases and slower cooling producing coarser growth.

CONCLUSION

- The study highlights how grain formation impacts material properties like strength, hardness, and stress distribution advances understanding of grain theory and fosters a deeper appreciation for the beauty in everyday materials.
- Random factors like cooling rates, alloy composition, and deformation create striking, unexpected patterns that are appreciated for their artistic qualities and demonstrates how random metallurgical processes result in functional and visually captivating structures.

REFERENCES

Sialloy. "Microstructure of Gray Cast Iron." *Sialloy*, 18 Dec. 2020, www.sialloy.com/blog/microstructure-of-gray-cast-iron.html.

Sn-Pb Microstructure vs. Aging." *ResearchGate*, 2013, www.researchgate.net/figure/Sn-Pb-Microstructure-vs-Aging_fig3_4255745.