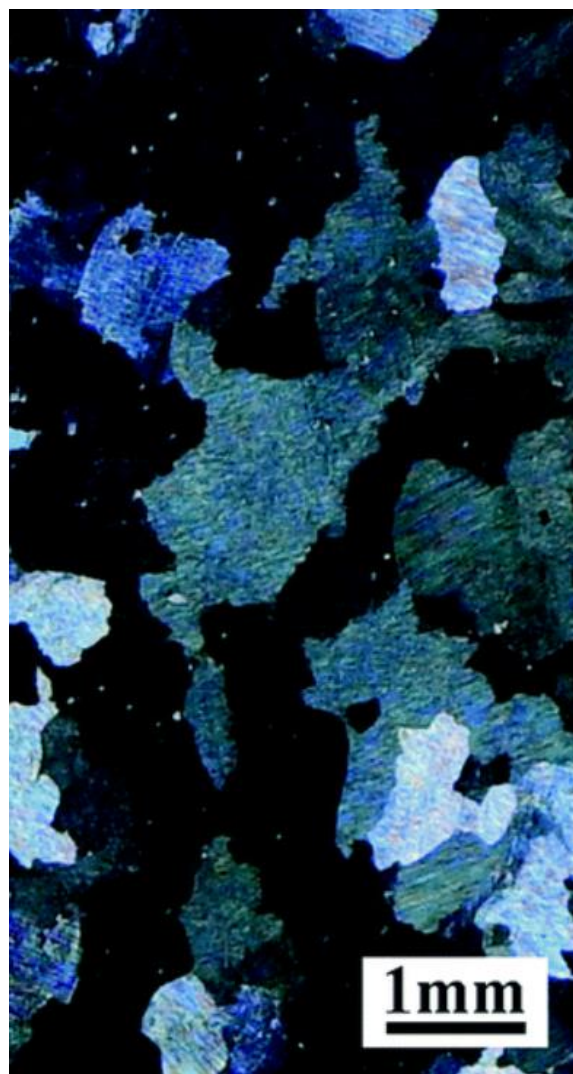
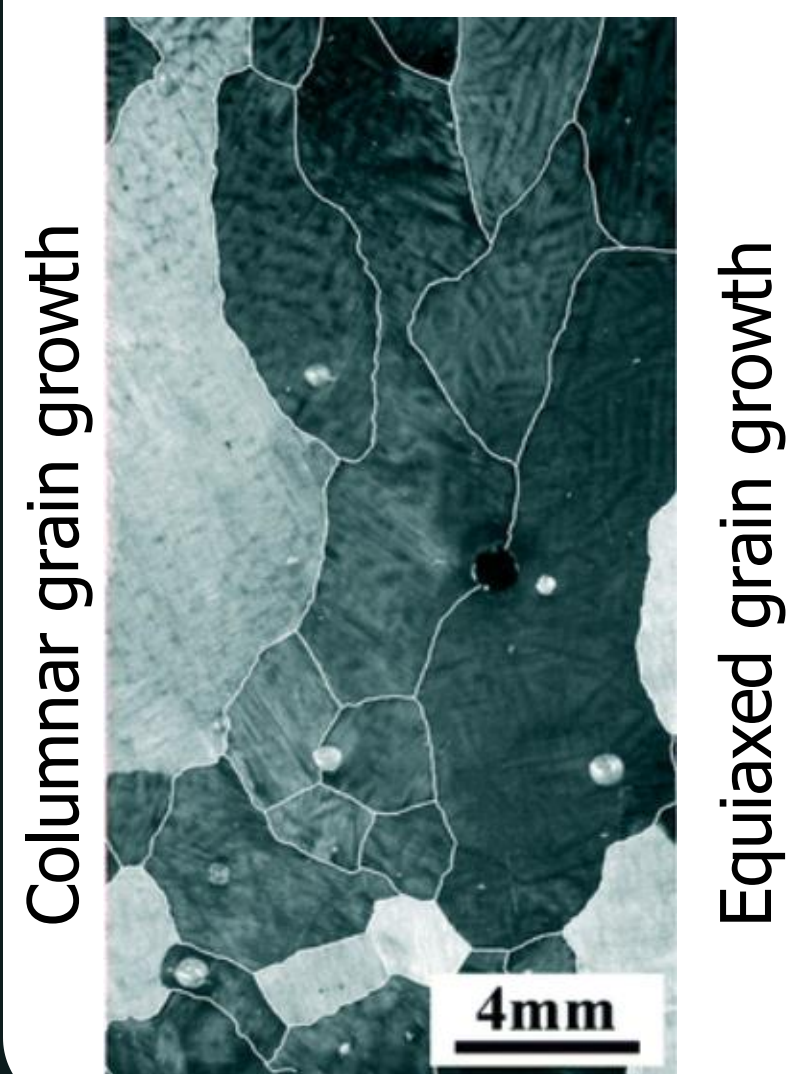


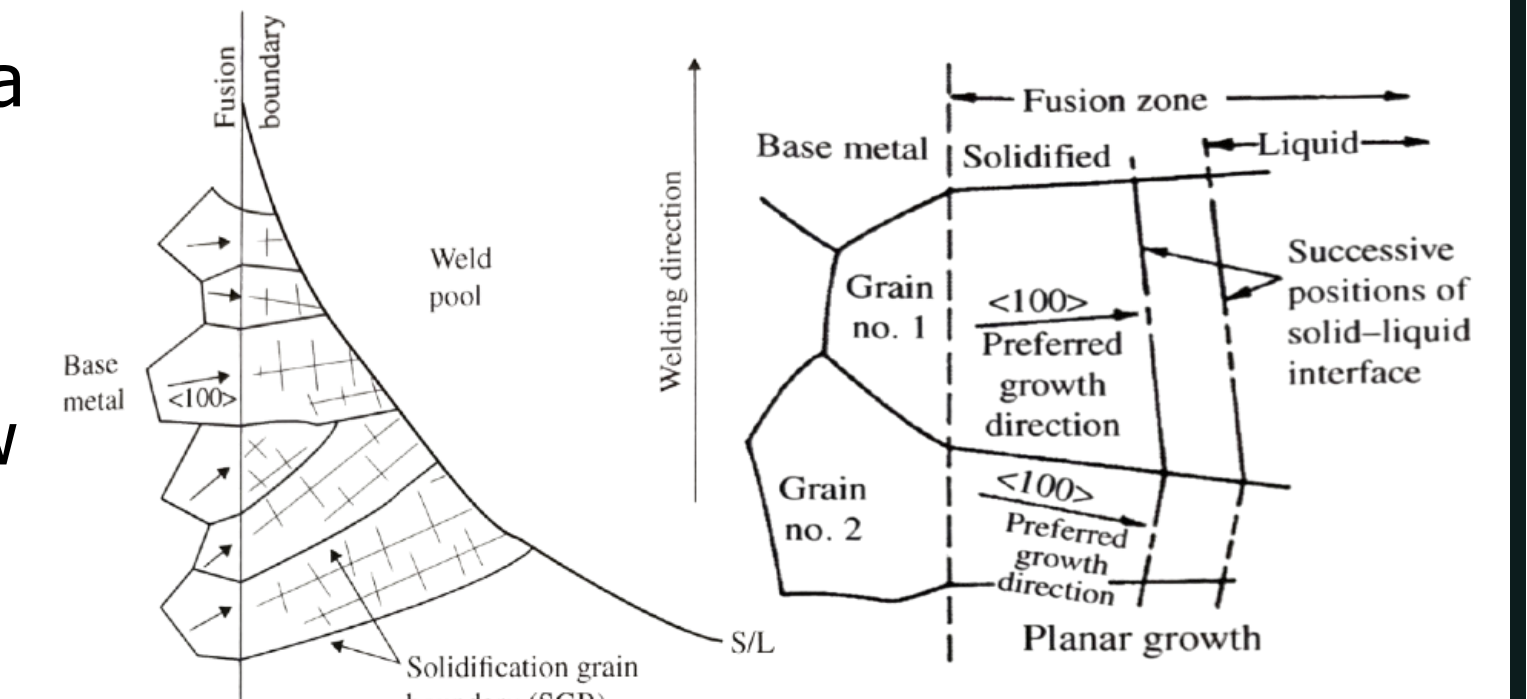
Background



Current Gas Tungsten Arc Welding (GTAW) methods commonly produce a coarse columnar grain structure in **Ti-6Al-4V**, resulting in a compromised microstructure and reduced mechanical properties.

This occurs due to high thermal gradients and slow solidification rates in GTAW. As the titanium alloy cools from the high-temperature beta (β) phase, grains grow **epitaxially** from the base metal with few nucleation sites, forming large, directionally solidified structures, leading to **anisotropy**.

To counter this, research is investigating **high-frequency/high-pulsing GTAW**. These rapid pulses may create stirring that promotes **new nucleation sites within the weld pool**, disrupting planar grain growth and encouraging finer, more equiaxed grains.



Planar growth in Ti-6Al-4V
Grains only nucleate from the base metal

Motivation

Ti-6Al-4V is valued for its **high strength-to-weight** ratio, corrosion resistance, and biocompatibility, making it ideal for **aerospace**, **medical devices** like pacemakers and prosthetics, and applications in the U.S. **Army**, **Navy**, and **nuclear power** generation.



The Blackbird, made of 85% titanium, was one of the fastest spy planes.

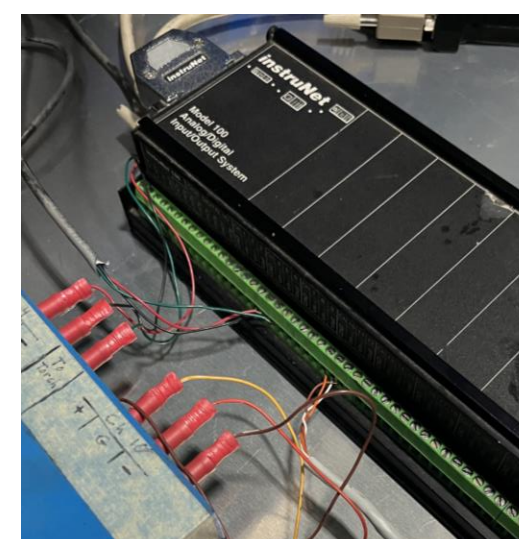
Objectives & Approach

Objectives

- Investigate the effects of high-frequency current pulsing GTAW on grain growth in additive Ti-6Al-4V weldments.

Approach

- Make a **baseline** weld at **135 A** with **no pulsation**.
- Develop initial welding procedure and parameters.
- Make weldments 5 beads high at **500**, **5000**, and **10000 Hz** using rapid pulsed current.
- For each frequency, perform welds at two current wave amplitude settings:
 - Low amplitude: $\sim 132.5\text{--}137.5$ A (± 2.5 A)
 - High amplitude: $\sim 35\text{--}235$ A (± 100 A)
- Average current held constant at 135 A across all welds.
- Collect accurate amperage and voltage data through a data acquisition (**DAQ**) system.
- Analyze microstructure and grain size of cross sections.

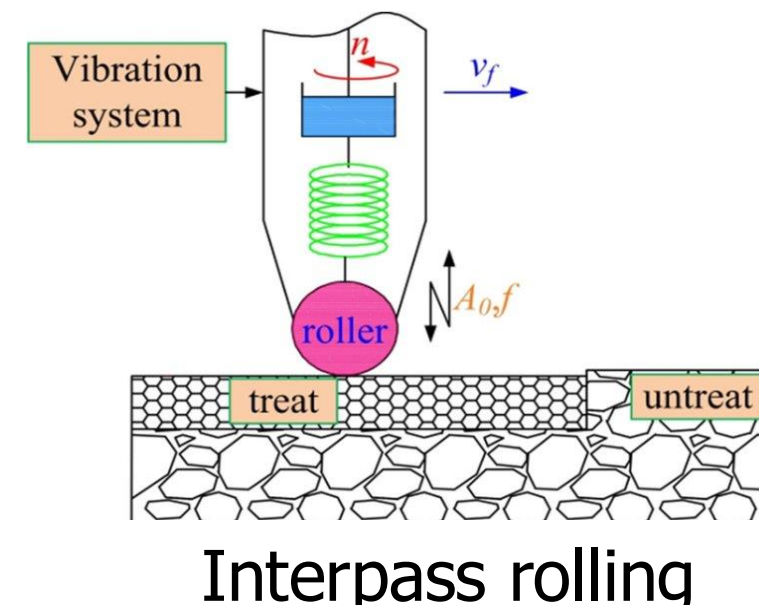


Conclusions

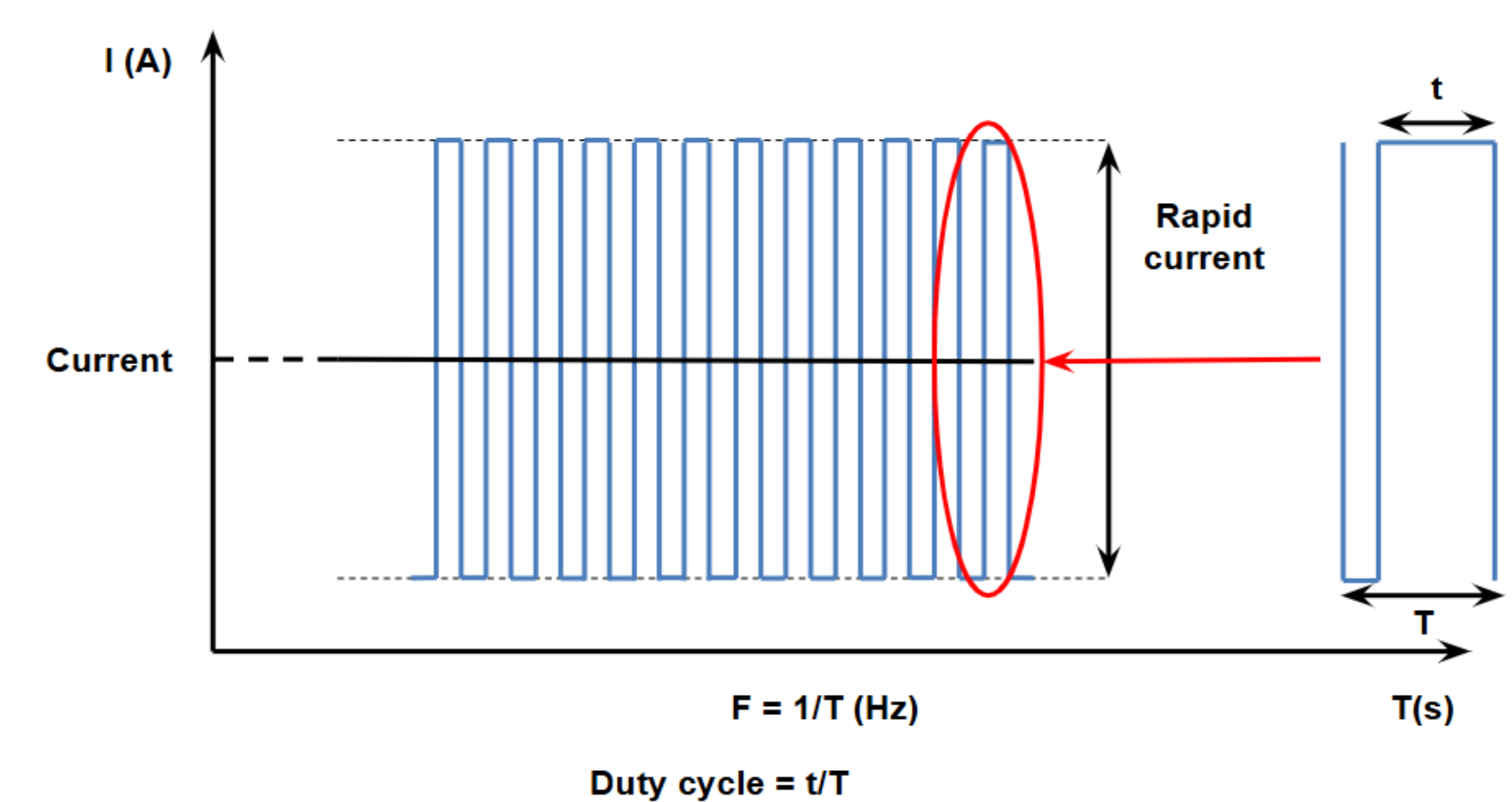
- Qualitatively, **high amplitudes** are effective at **reducing grain size**.
- At higher frequencies (approaching 10 kHz), the pulsing is less effective at reducing grain size.
- Optimal combination** of **frequency** and **amplitude** is necessary for best results.

Future Work

- Find **optimal pulsing parameters** to reduce grain size.
- Study interpass **rolling** and ultrasonic **peening** effects on Ti-6Al-4V welds.
- Test **heat input** and **interpass temperatures** to enable welding without shielding.
- Perform **mechanical testing** to assess the impact of grain refinement on weld performance.



Results & Discussion



Using **rapid pulsation**, as illustrated in the figure above, the weld beads below were produced and analyzed for their grain structure.

Low amplitude (± 2.5 A) High amplitude (± 100 A)

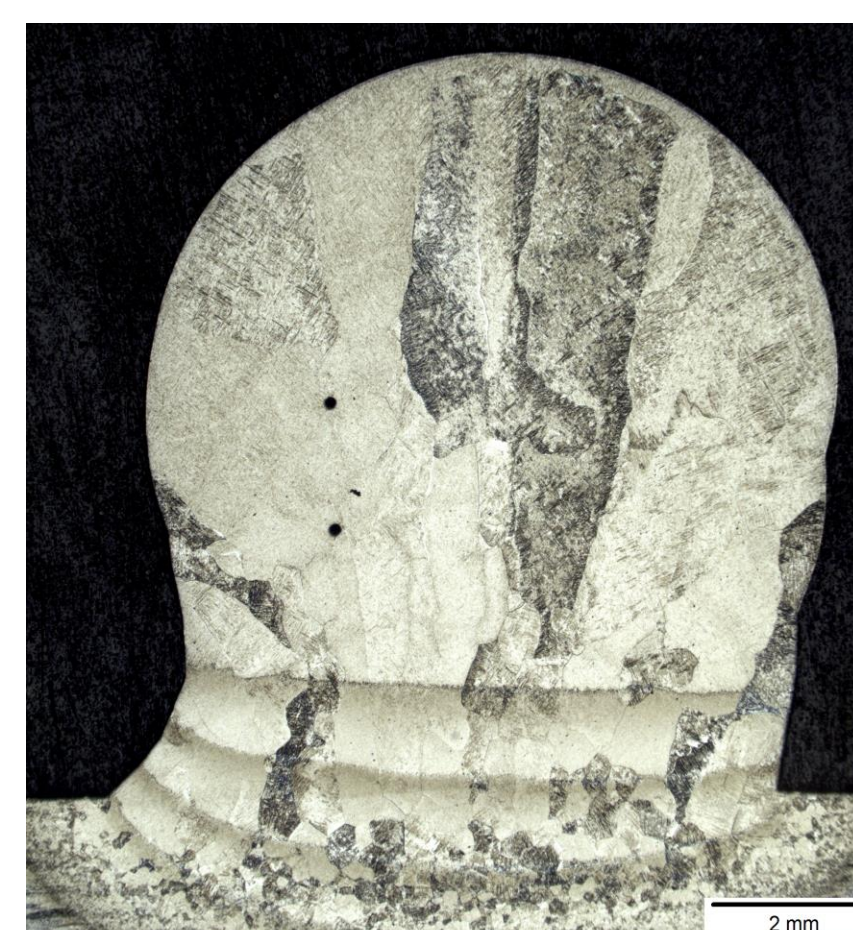
500 Hz



5000 Hz



10000 Hz



"Center Proprietary"



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