MICROSTRUCTURAL REFINEMENT AND IMPROVEMENT OF MICROHARDNESS IN A HYPOEUTECTIC AL-FE ALLOY TREATED BY LASER SURFACE REMELTING

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INTRODUCTION

- There is an increasing interest in Al-Fe alloys for applications demanding high electrical conductivity [1] and/or good thermal stability [2].
- However, the presence of coarse Al_3Fe plate-like IMC does not provide the required conductivity and mechanical response. One of the four main requirements for designing Al-Fe wire, with a good balance considering strength and electrical conductivity, is IMCs finely dispersed in the Al-matrix [1].
- A possibility to obtain a highly refined microstructure in as-cast alloys is through the **laser surface remelting** (**LSR**) treatment, where the treated region is remelted and reaches cooling rates at the range of 10^3-10^8 K/s [3]. Due to these extremely high cooling rates, the microstructure can be 100 times more refined than that untreated [4]. Besides, as the laser equipment could be automatized, components with complex geometries are able to be treated.

OBJECTIVES

- This work aims to investigate the influence of process parameters of LSR treatment (average **beam power P**, **scanning speed v** and **working distance z**) on the remelted tracks at the surface of as-cast **Al-1wt.%Fe** alloy.
- In order to evaluate their influence on the remelted pool:
  - **Depth and width**;
  - **Microstructure**;
  - **Microhardness**.

METHODS

- A previously solidified Al-1wt.%Fe was submitted to different combinations of **LSR parameters** shown on **Fig. 1**

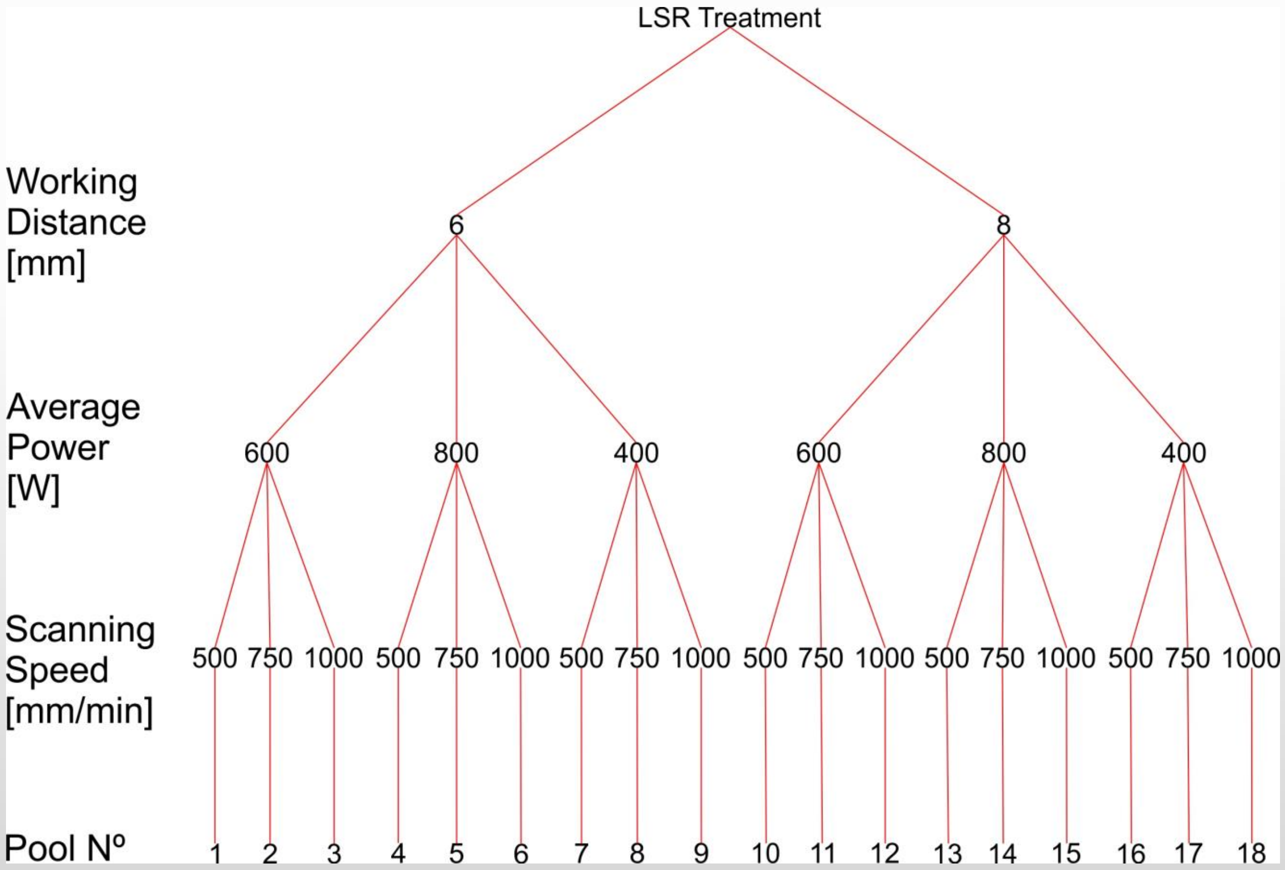

Figure 1. Experiment sample tree parameters for all produced laser remelted pools.

RESULTS

- For z_1 **= 6 mm**, pools dimensions and overall quality were assed trough the optical images presented on **Fig. 2**

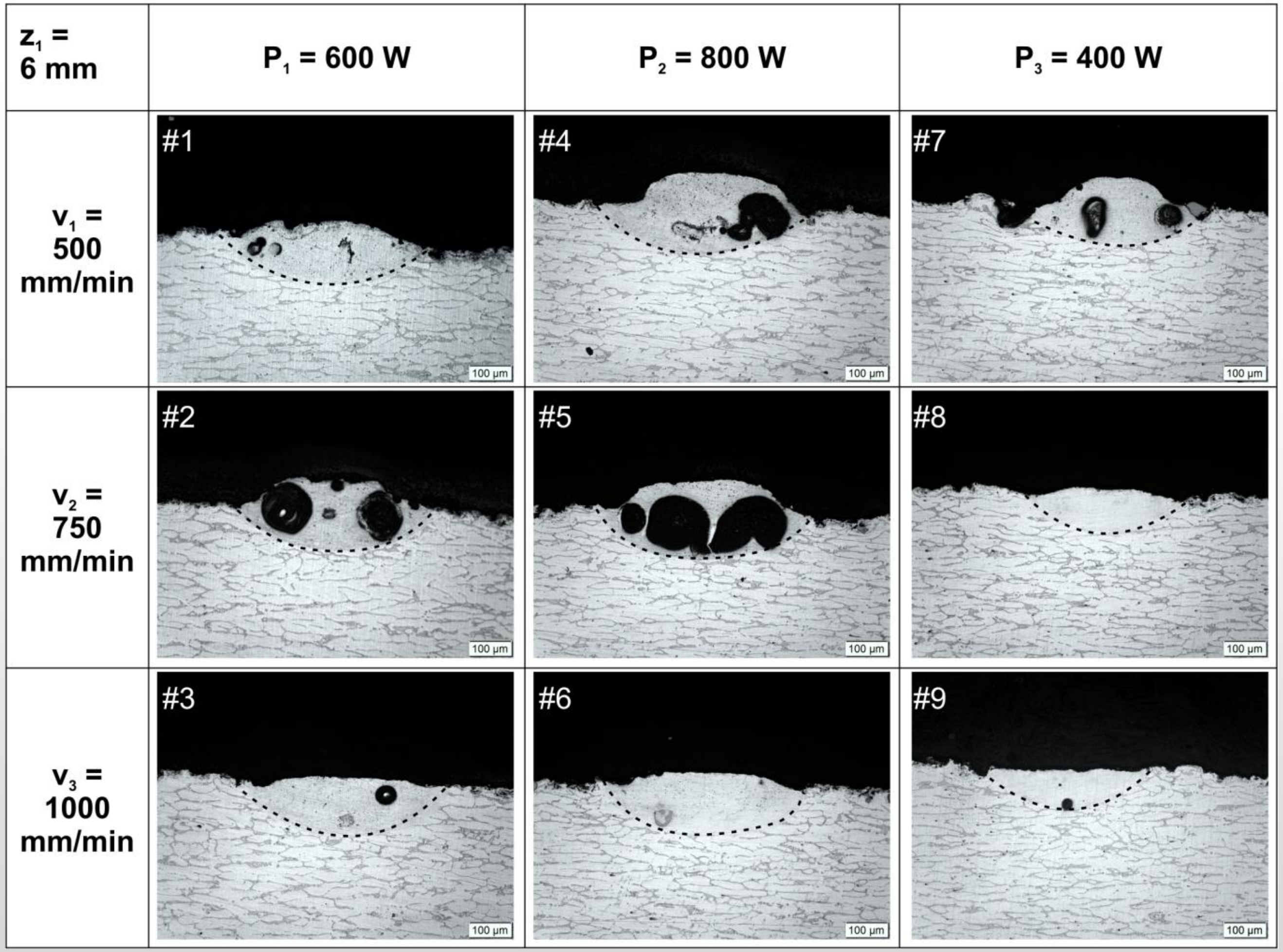

Figure 2. Optical microscope images of laser remelted pools #1 to #9.

RESULTS

- For z_1 **= 8 mm**, pools dimensions and overall quality were assed trough the optical images presented on **Fig. 3**

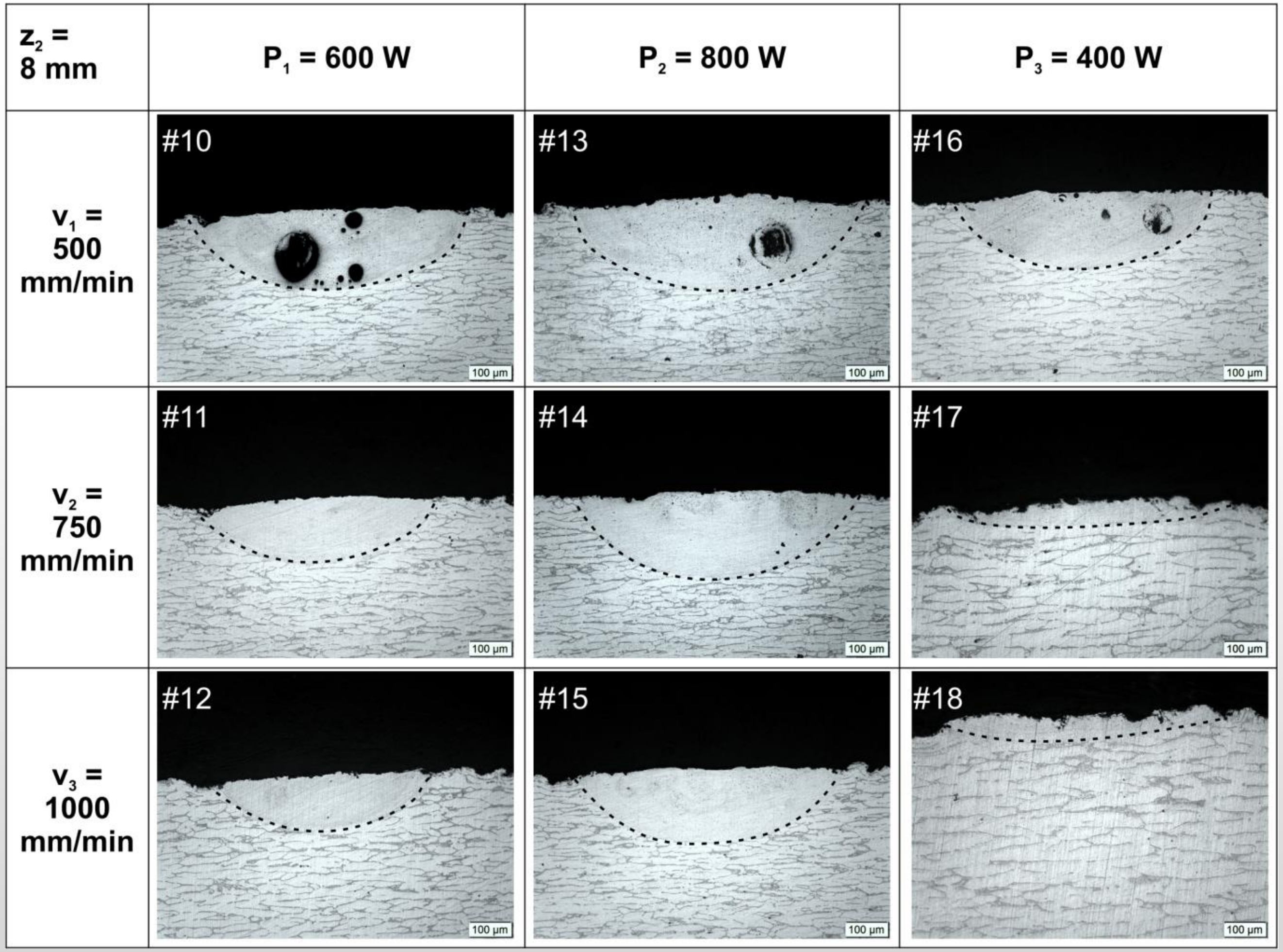

Figure 3. Optical microscope images of laser remelted pools #10 to #18.

RESULTS

- Table 1 sumarizes **quality** and **dimensional** assessment of the remelted pools.

z[mm]	P[w]	v [mm/min]	Pool Nº	Quality	Depth [µm]	Width [µm]
6	600	500	1	Blisterig	-	-
		750	2	Blisterig	-	-
		1000	3	Deformation	-	-
	800	500	4	Blistering	-	-
		750	5	Blistering	-	-
		1000	6	Deformation	-	-
	400	500	7	Blistering	-	-
		750	8	Good	114	400
		1000	9	Good	105	386
8	600	500	10	Good	200	686
		750	11	Good	182	671
		1000	12	Good	170	549
	800	500	13	Good	242	710
		750	14	Good	214	682
		1000	15	Good	177	654
	400	500	16	Porosity	145	523
		750	17	Low Depth	-	-
		1000	18	Low Depth	-	-

Table 1. Quality and dimensions of laser remelting treated pools

RESULTS

- Due to the **high cooling rates ($\dot{T}$)** promoted by LSR treatment, the resulting microstructure had an **avarege refinement** in the order of **14 times**, when compared to the untreated substrate.
- **Microstructural spacing (λ)** had a low variance between pools, in other words, the different parameter combination resulted in similar microstructures. Suggesting that values approximate to λ_{ext} (extremum spacing) have been reached [5].

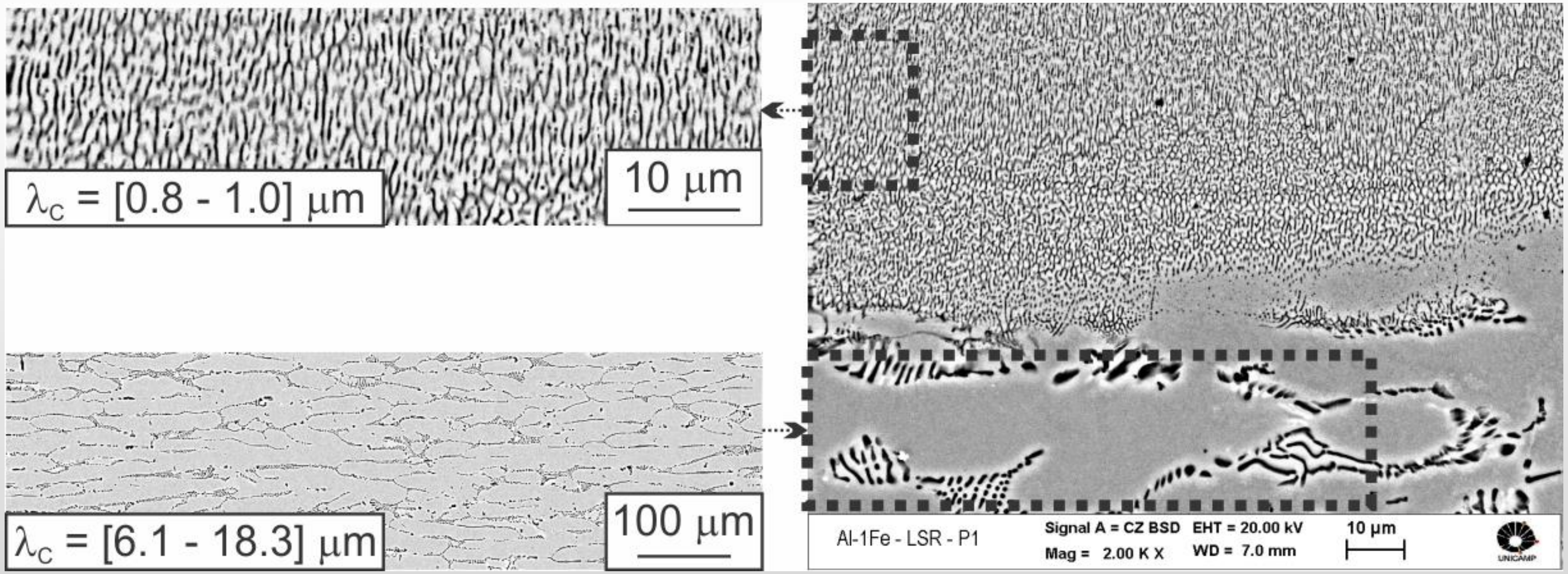

Figure 4. Microstructural interphase spacing as function of cooling rate ($\dot{T}$)

RESULTS

- Near the substrate, a **cellular structure** develops because of the lower growth rates in this region. Hovewer its length is about 10-20 µm, afterwards, as growth rate increases, a **finer dendritic structure** appears. This transition is depicted on Fig 5. Transition between layers are also highlighted, those are characteristical of **epitaxial growth**.

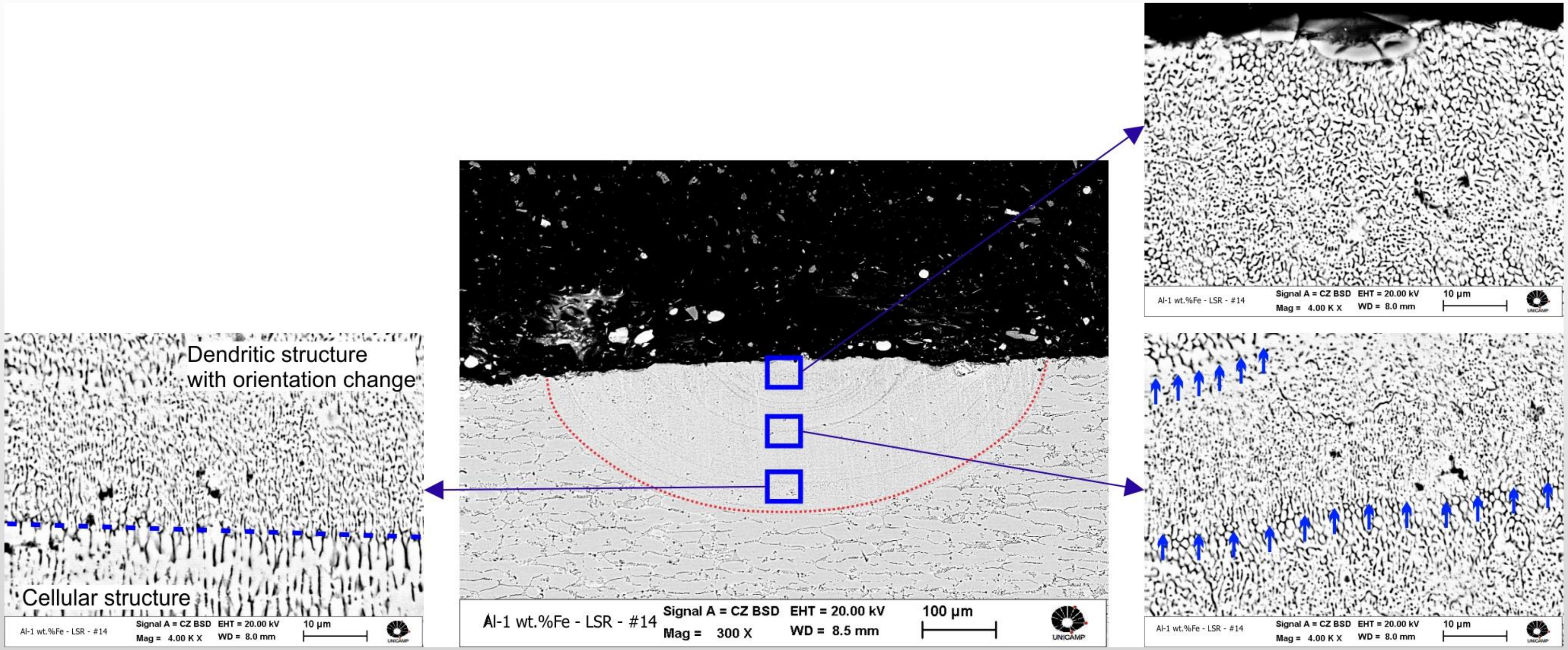

Figure 5. Microstructure of the remelted track cross section sample #14.
Near substrate, middle and near surface zones are highlighted.

RESULTS

- An **increase in microhardness** was already expected, what is worth of noticed is that it even exceeds the extrapoletated function of the solidified alloy shown on **Fig 6**

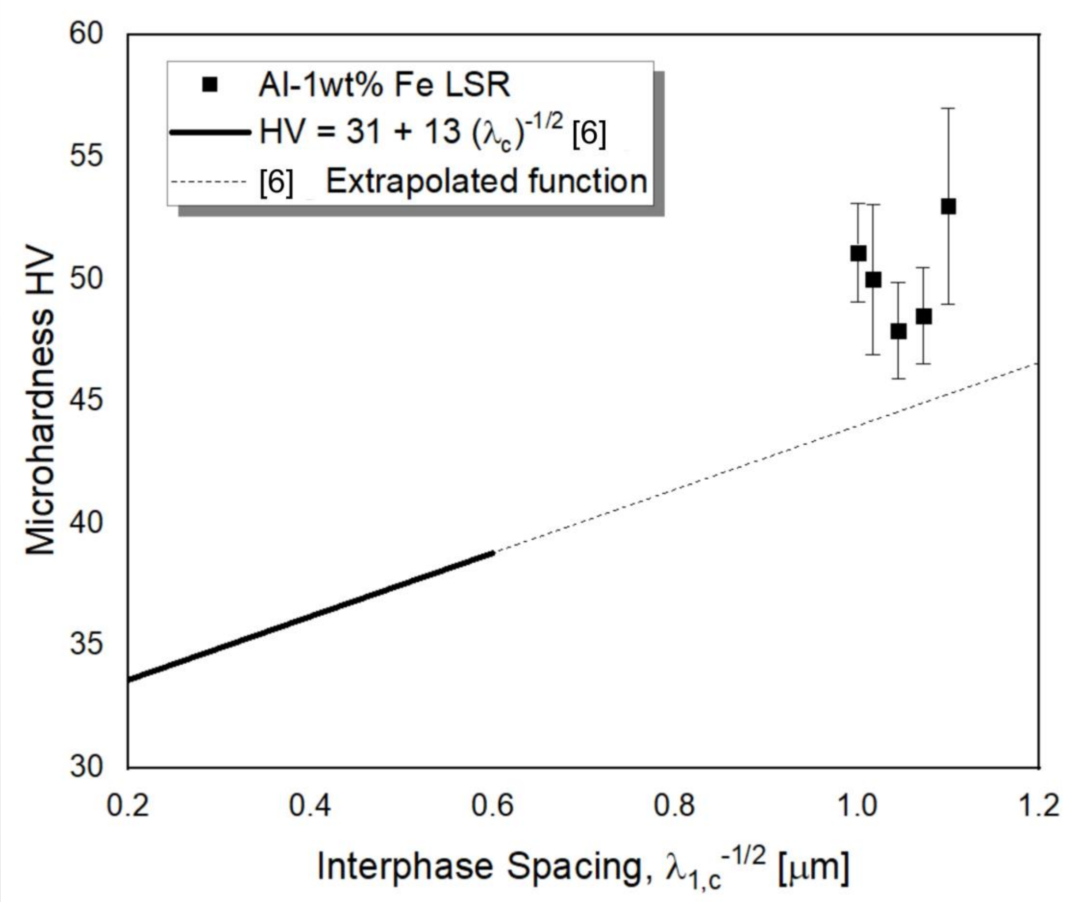

Figure 6. Microhardness as function of interphase spacing for Al-1wt% Fe LSR treated alloy. Comparing to the directionally solidified alloy.

CONCLUSIONS

In the present study, a laser surface remelting treatment was performed on a **Al-1wt.%Fe** sample, and the following conclusions were drawn:

1. An operational parameters map, including **laser beam scanning speed, average power** and **working distance** was proposed to asses which treatments produce defects and which produces pools with higher widths and depths.

2. **LSR** operational **parameters** directly **affect the dimensions of treated pools**, however direct correlation with microstructural spacing could not be noticed.

3. When comparing with the untreated substrate, **microstructural spacing** from remelted tracks has refined in an order of **14 times** and the **microhardness** has **improved**.

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