KEK experiences in SCRF cavity fabrication

TTC meeting WG1

2014/March/25

Kensei Umemori, Yasuo Ajima, Hitoshi Inoue, Takayuki Kubo, Takayuki Saeki, Yuichi Watanabe, Seiya Yamaguchi, Masashi Yamanaka (KEK)

Reference:「Study on optimum electron beam welding conditions for superconducting accelerating cavities」Takayuki Kubo et. al, SRF2013

KEK-CFF (Cavity Fabrication Facility)

Clean room 19m x 14m x 5m (Height)

Class-100,000 / ISO 8 (Specification)

EBW machine

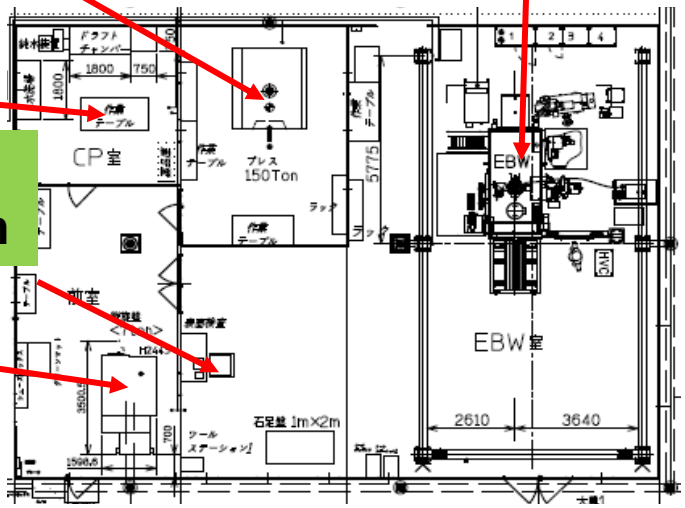
SST EBOCAM KS110-G150 KM-CNC

Press machine

Chemical treatment

Vertical lathe

Surface inspection



Clean room floor layout of CFF

Recent activities

- Nb sample EBW test
- 9cell STF cavity(Fine grain)
- 1cell large grain cavity

Contents

(1) EBW optimization for fine grain Nb samples

- EBW parameter: beam current, beam energy, focusing, direction of beam/work, defocusing etc…
- Condition for stable EBW
- Geometry of EBW welding

(2) EBW study for Large grain Nb samples/cells

- Comparison between LG/FG
- Dependence on groove surface thickness

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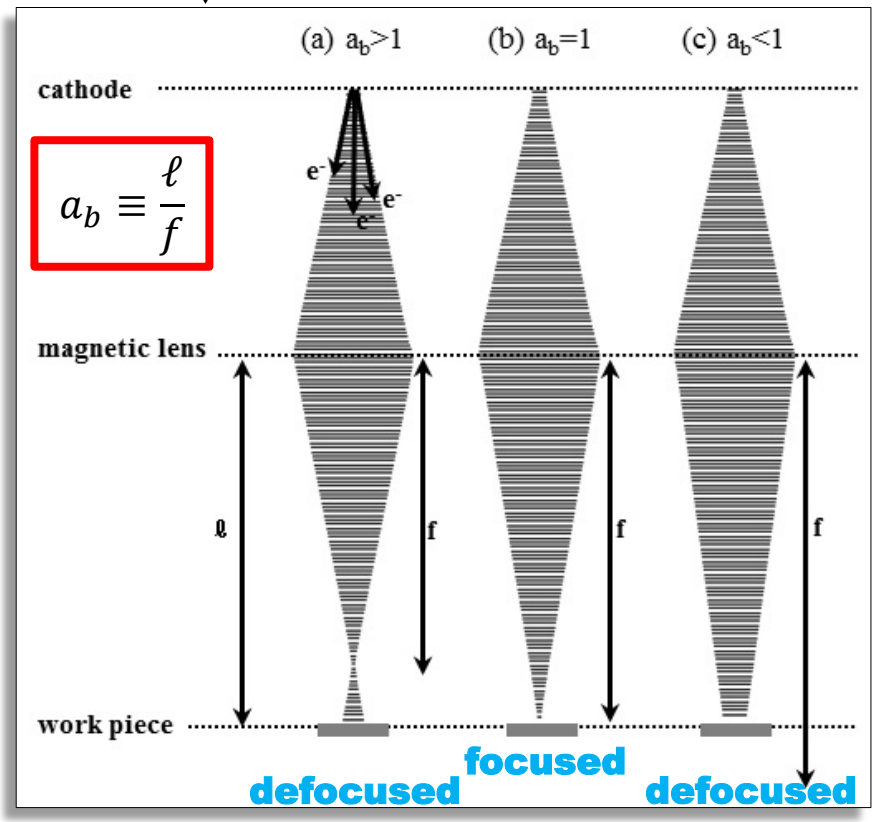
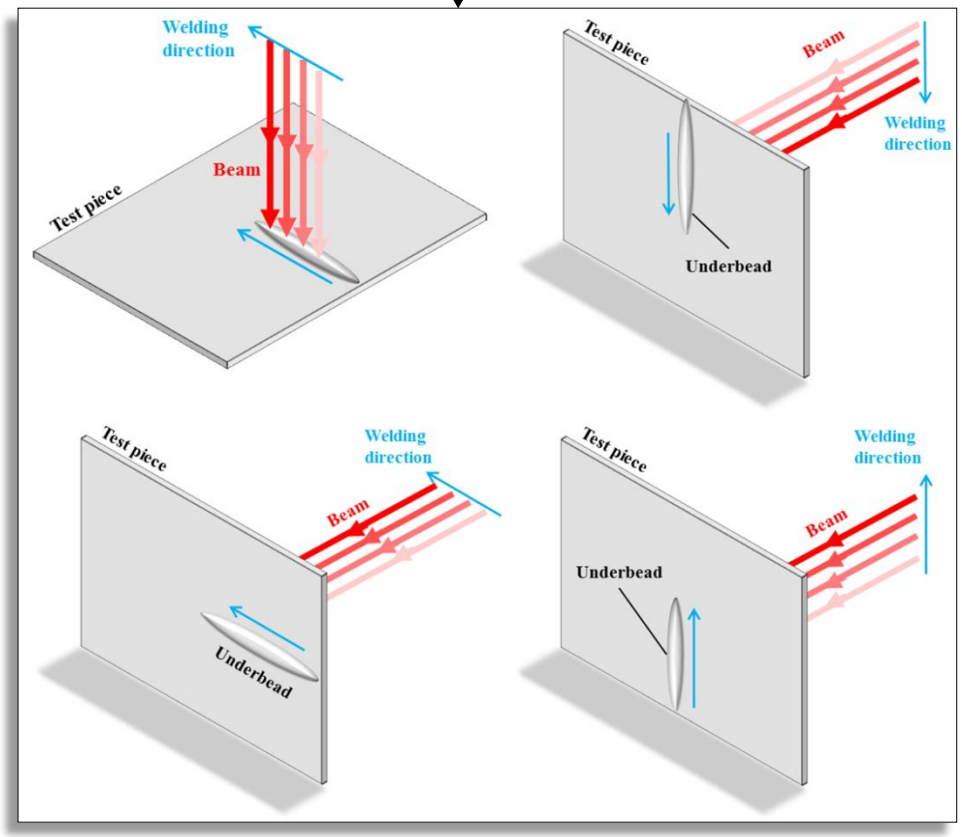
EBW parameters

1. **Combinations of generator and welding direction,**
2. **Accelerating voltage, V_a (kV),**
3. **Beam current, I_b (mA),**
4. **Welding speed, v (mm/s),**
5. **a_b-factor**

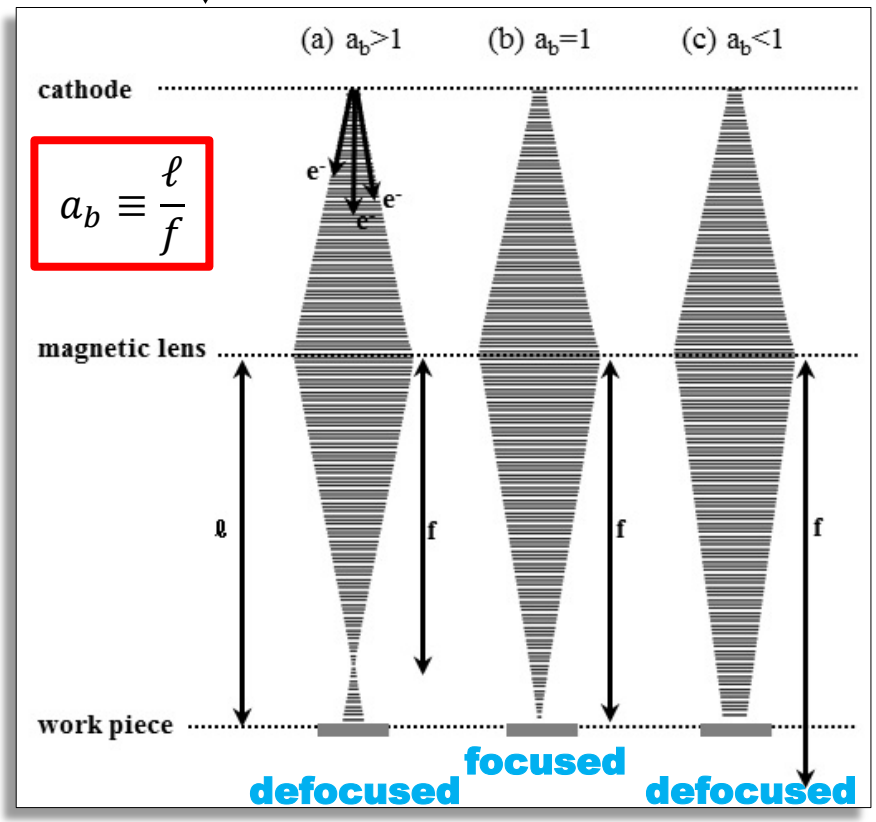


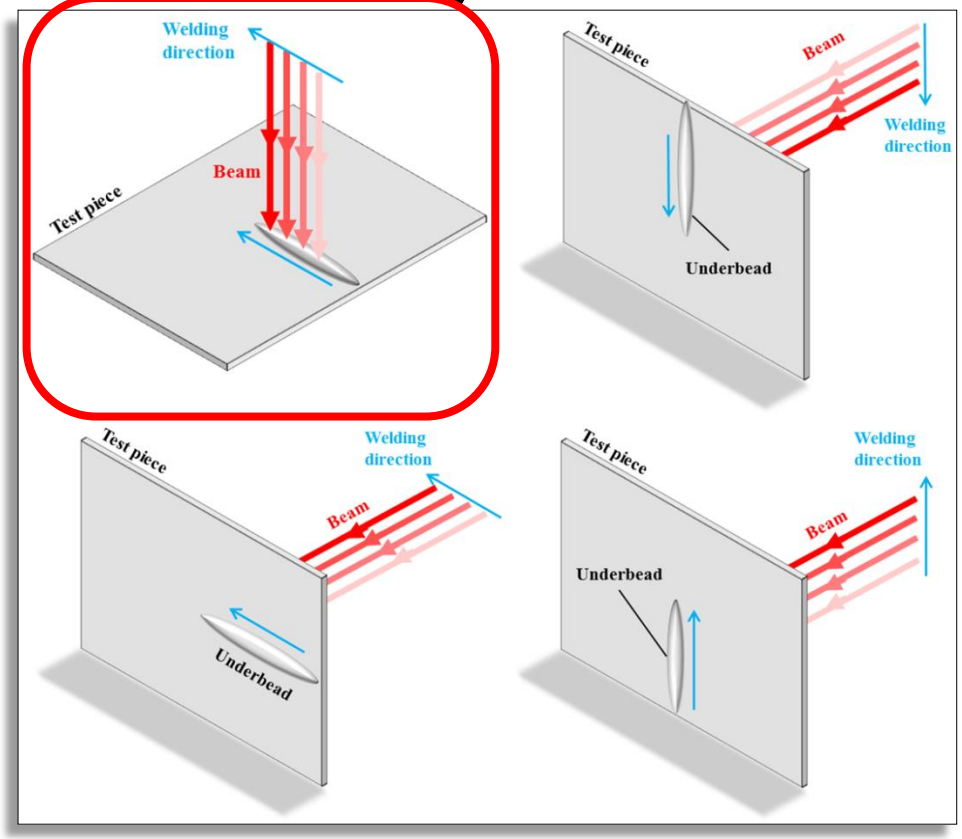


EBW parameters

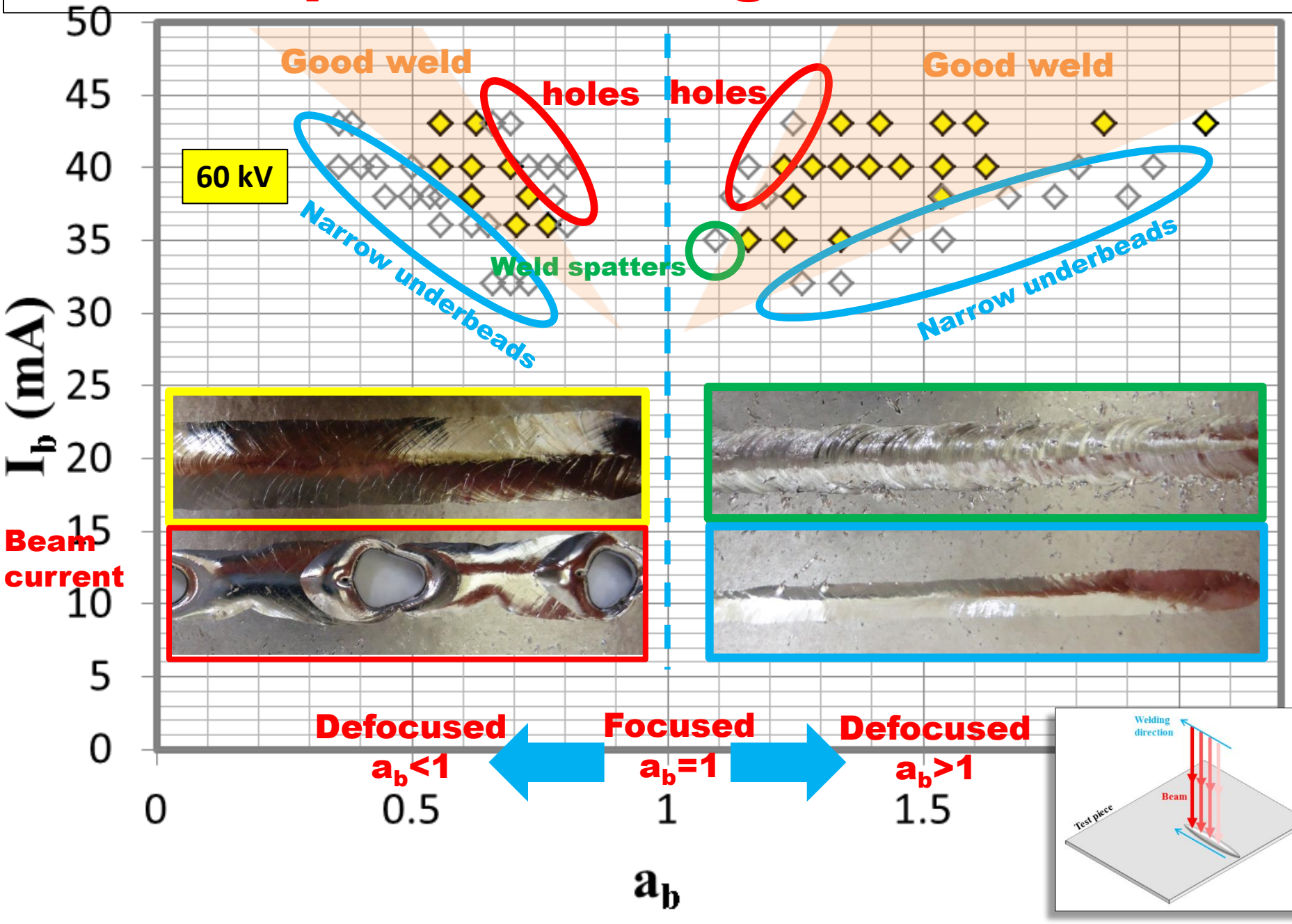
1. Combinations of generator and welding direction,
2. Accelerating voltage, V_a (kV), → 60, 90, 120, 150kV
3. Beam current, I_b (mA),
4. Welding speed, v (mm/s), → fixed to 5mm/sec
5. a_b-factor

Oscillation was not applied

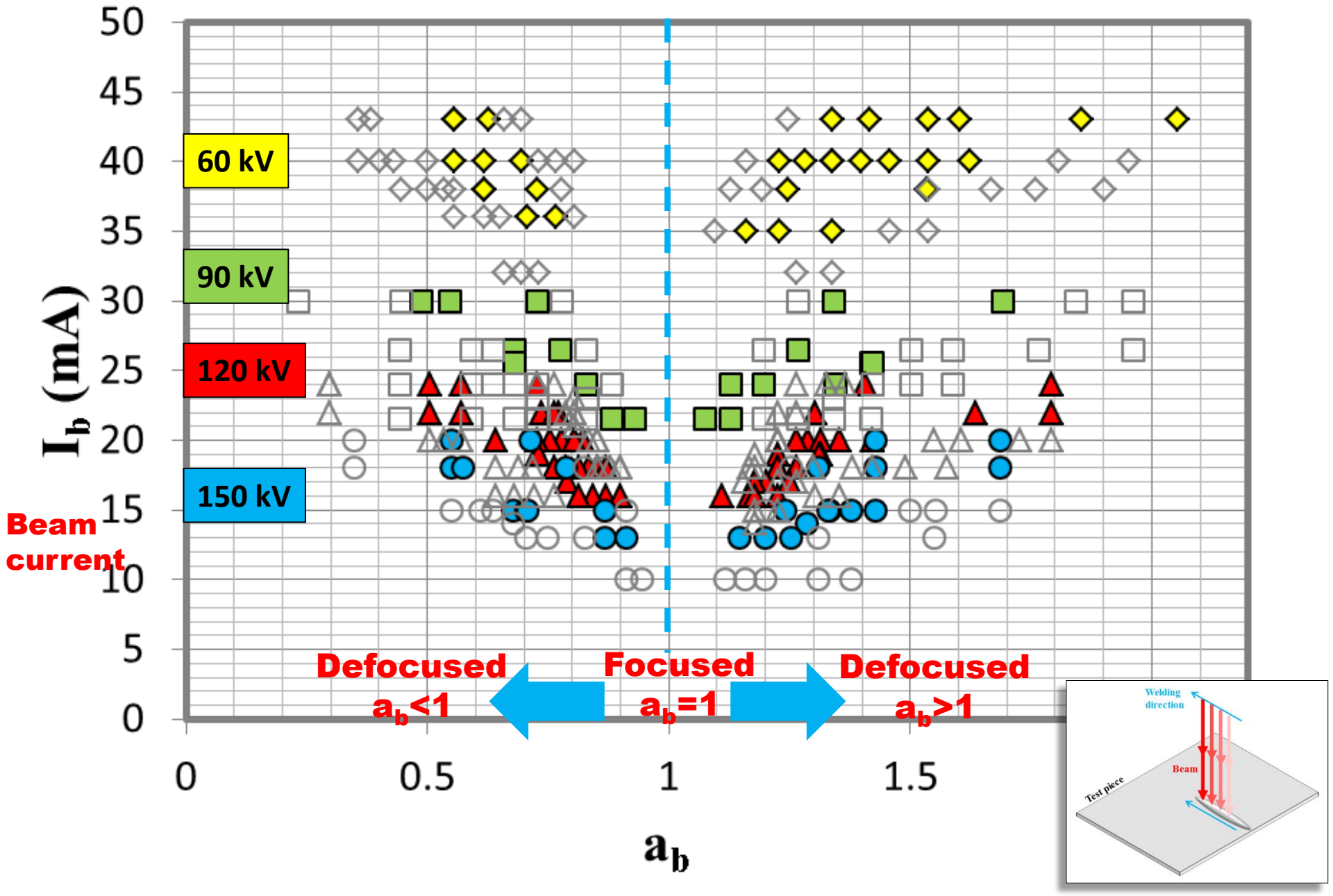




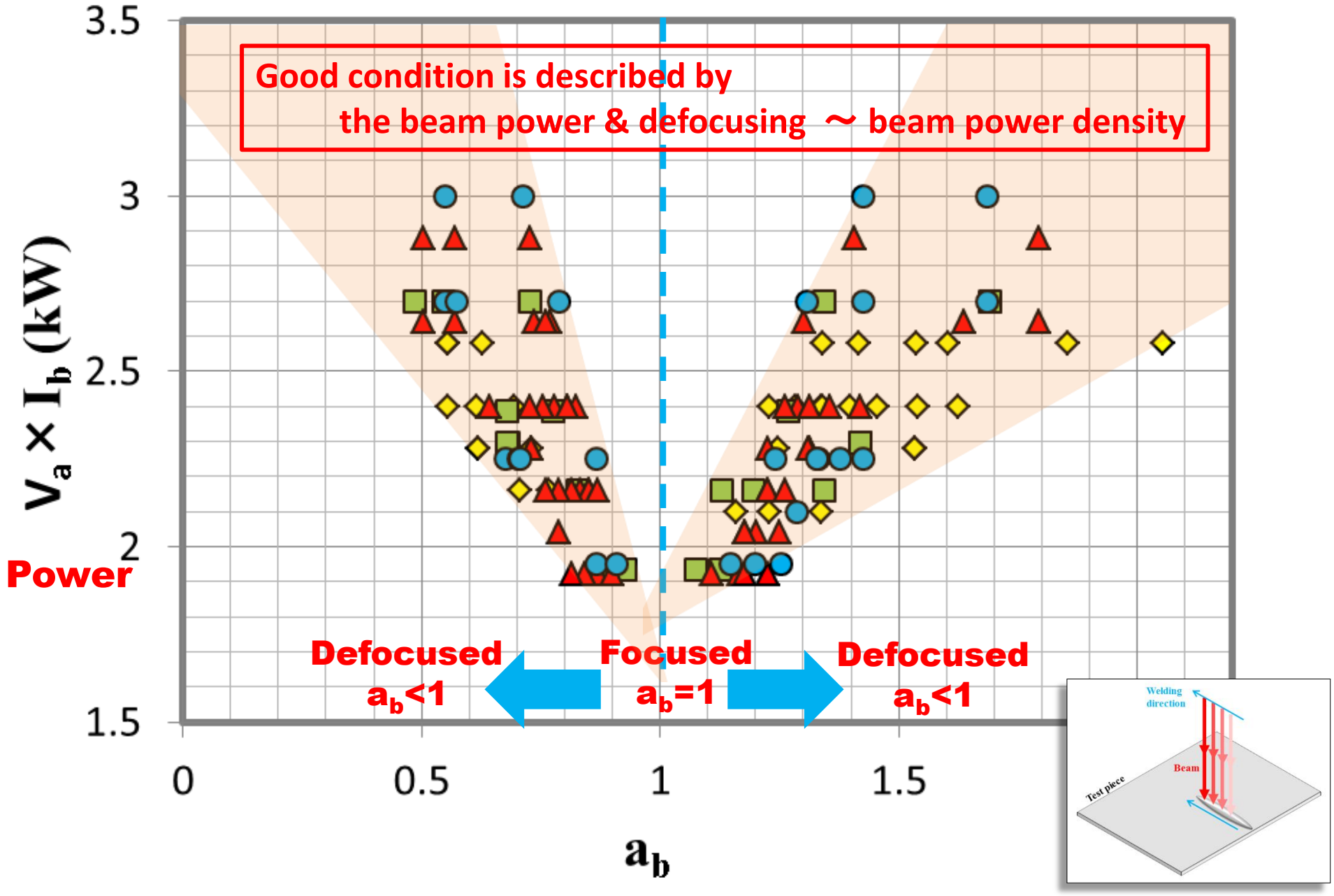
Good parameter-regions for 60kV



Good parameter-regions for 60/90/120/150 kV



Good parameter-regions for 60/90/120/150 kV



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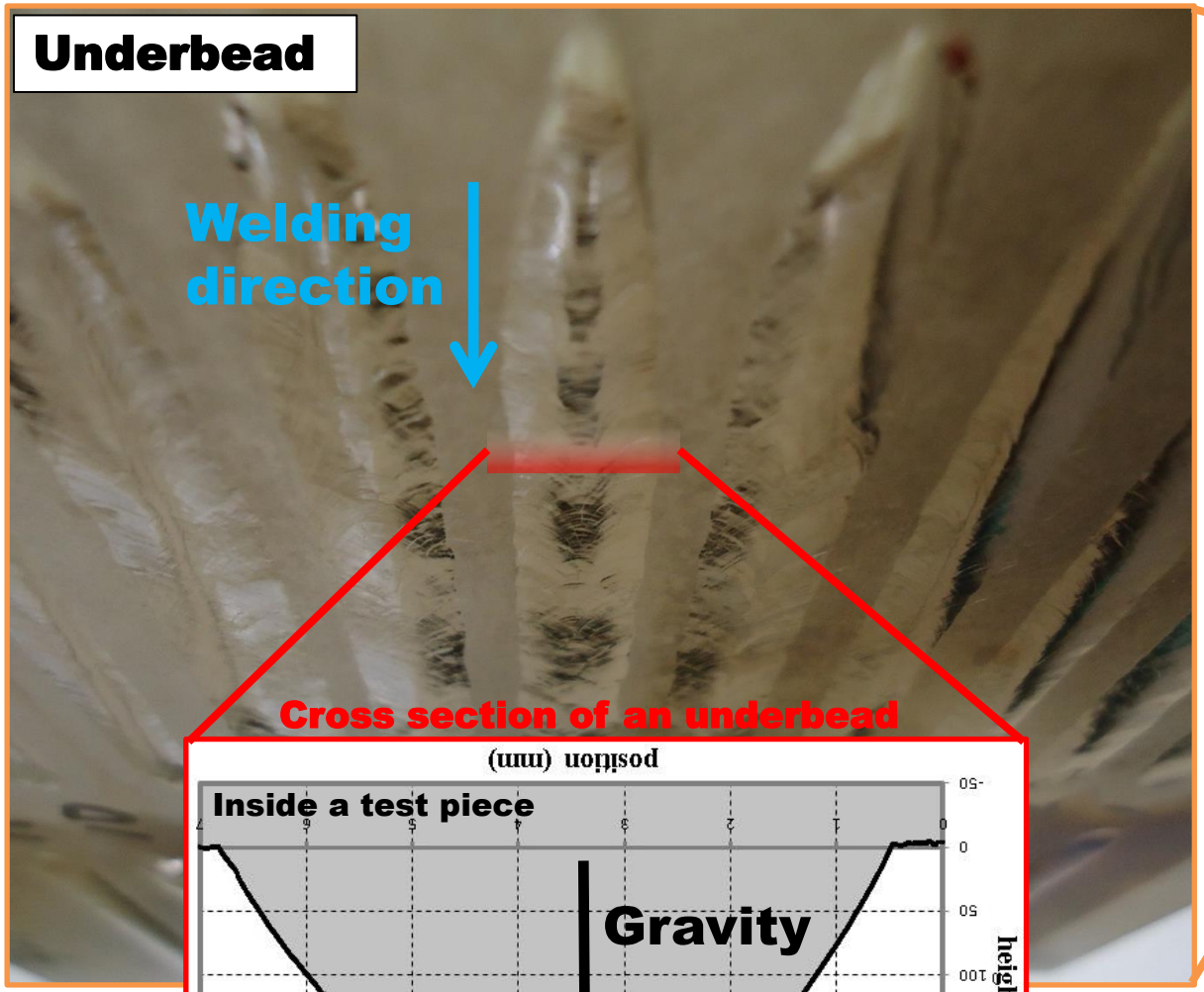
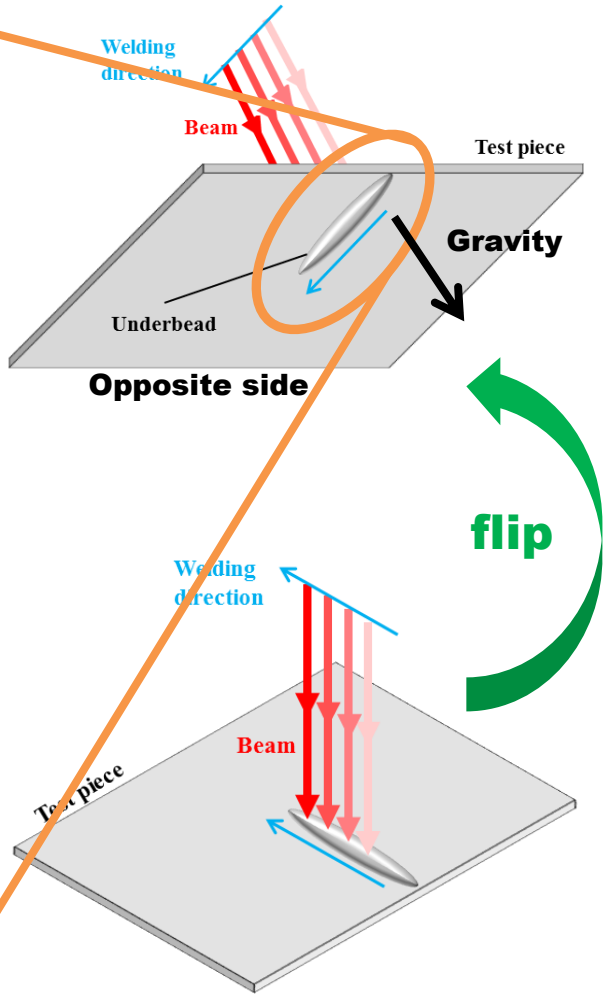
- Dependence on groove surface thickness

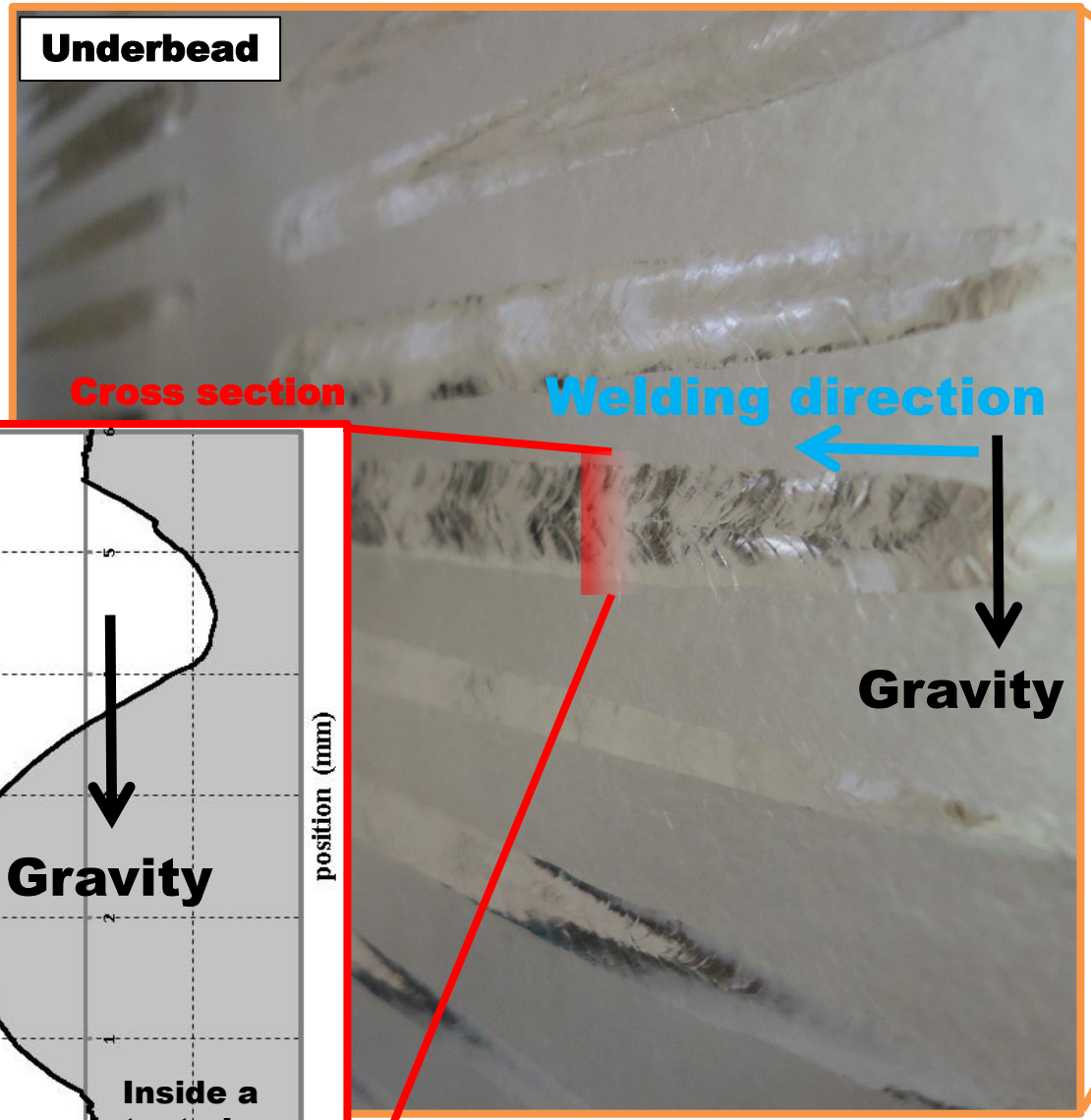
Underbead geometry (case (a): V-H)

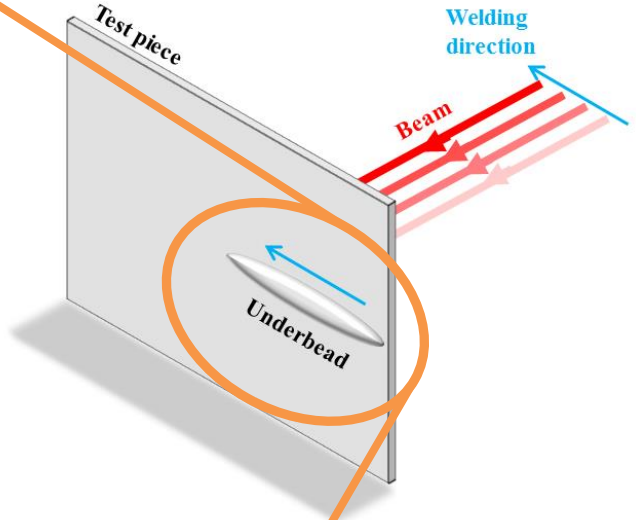




Case (a)
Vertical gun direction and
Horizontal welding direction.

Underbead geometry (case (b): H-H)

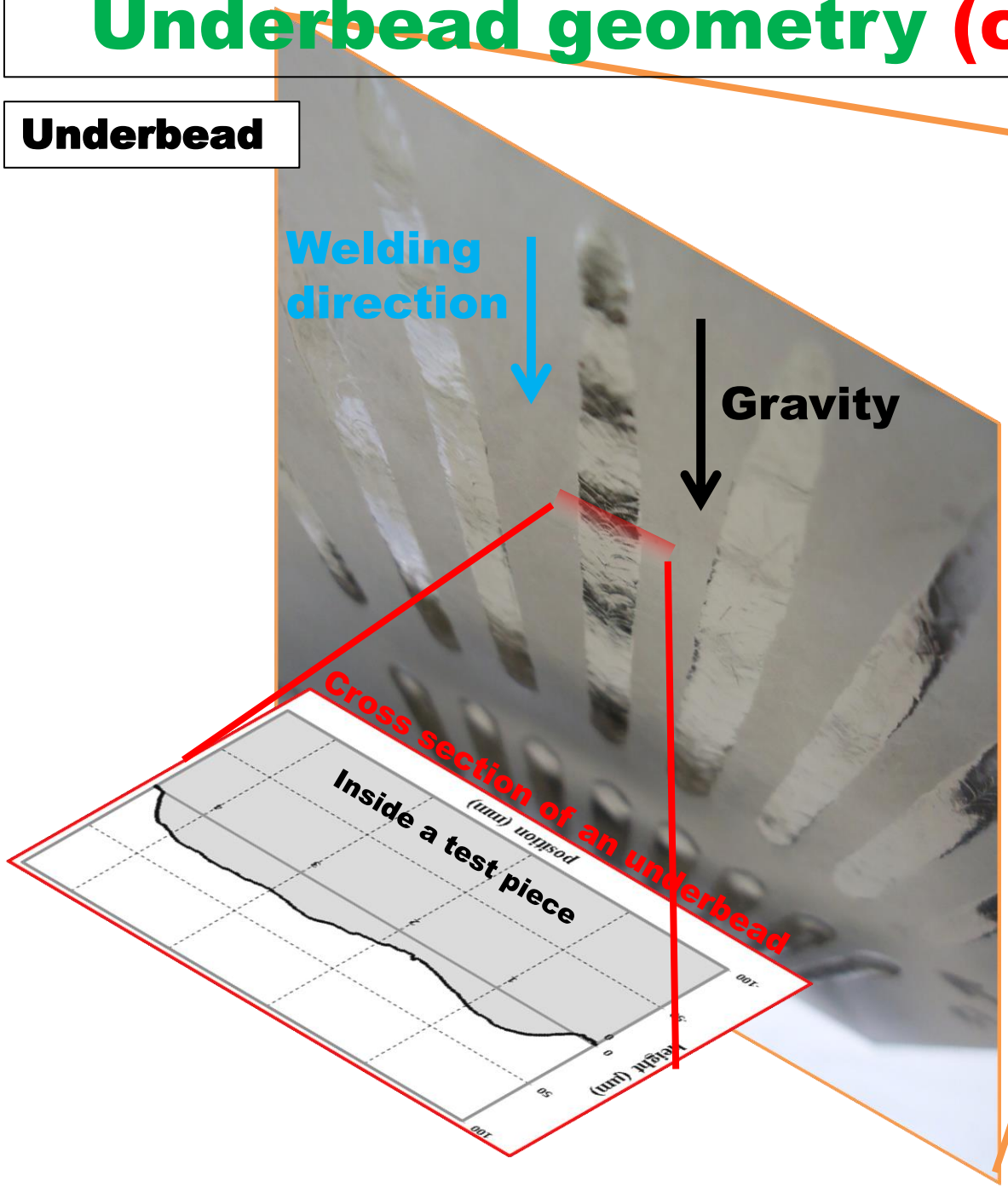


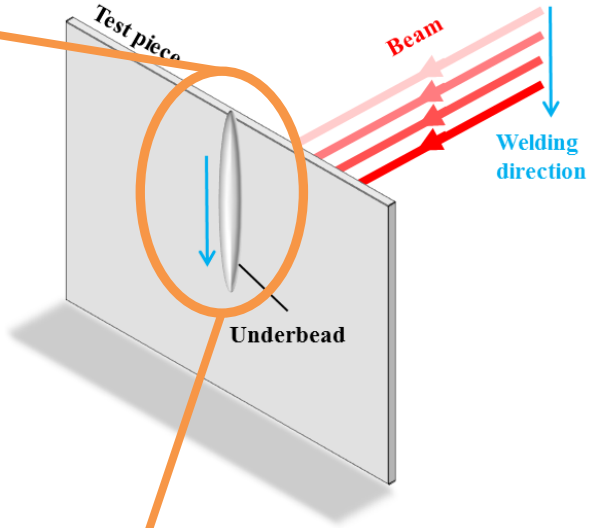


Case (b)
Horizontal gun direction and
Horizontal welding direction.

Underbead geometry (case (c): H-D)

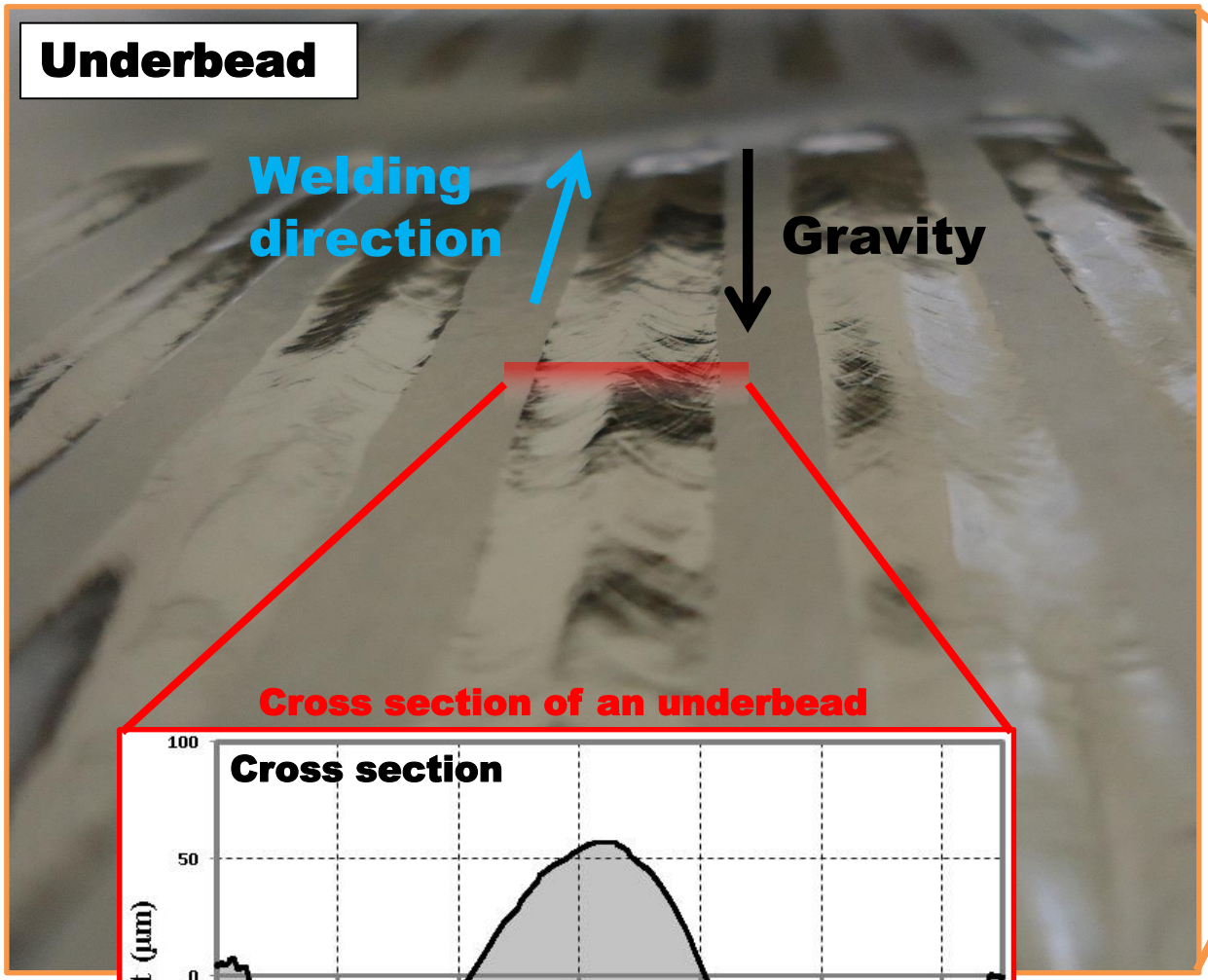
Underbead

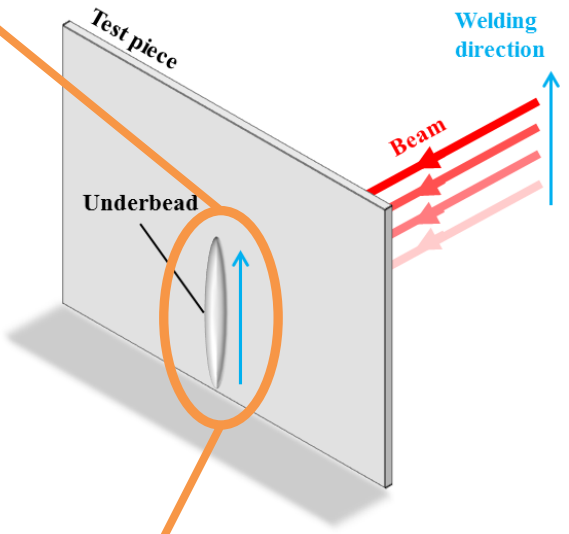




Case (c)
Horizontal gun direction and
Downward welding direction.

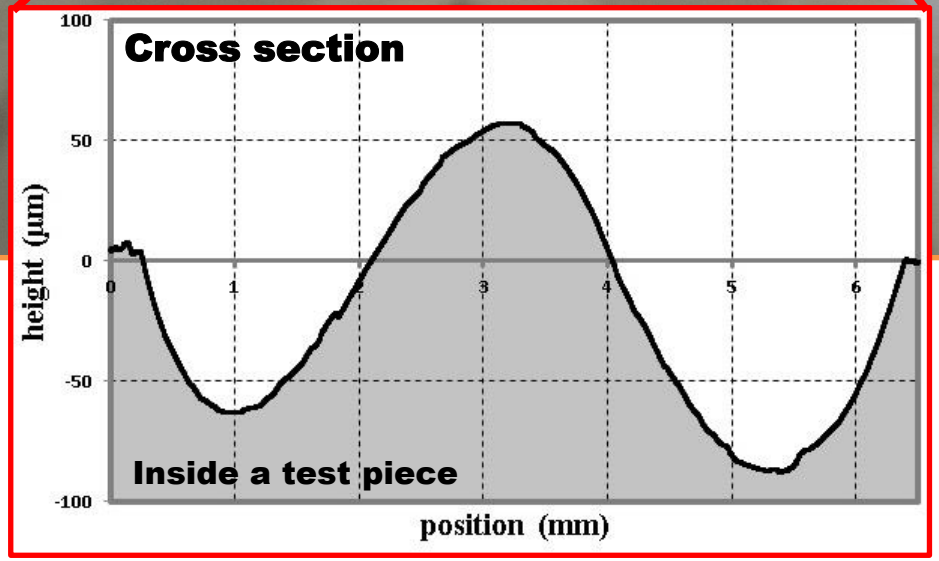
Underbead geometry (case (d): H-U)



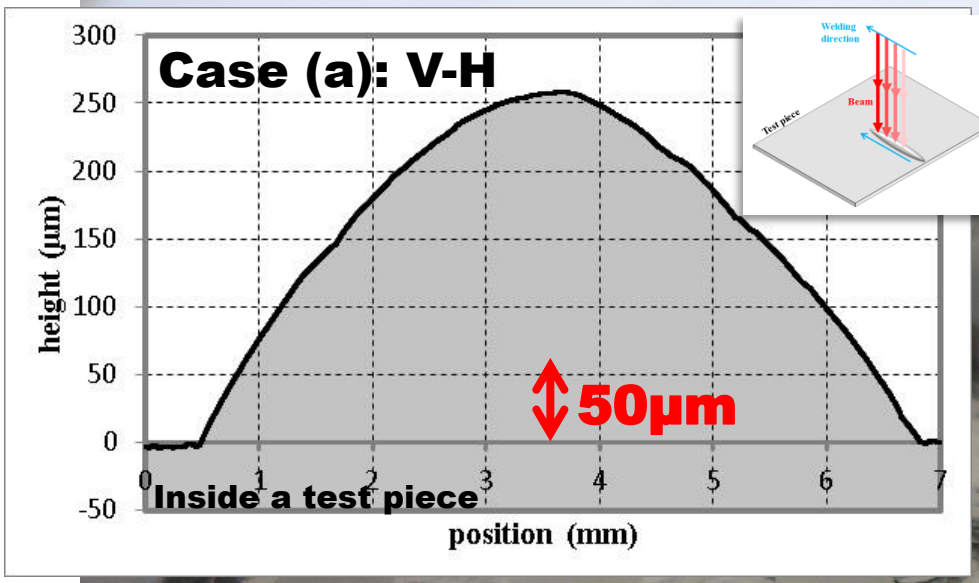


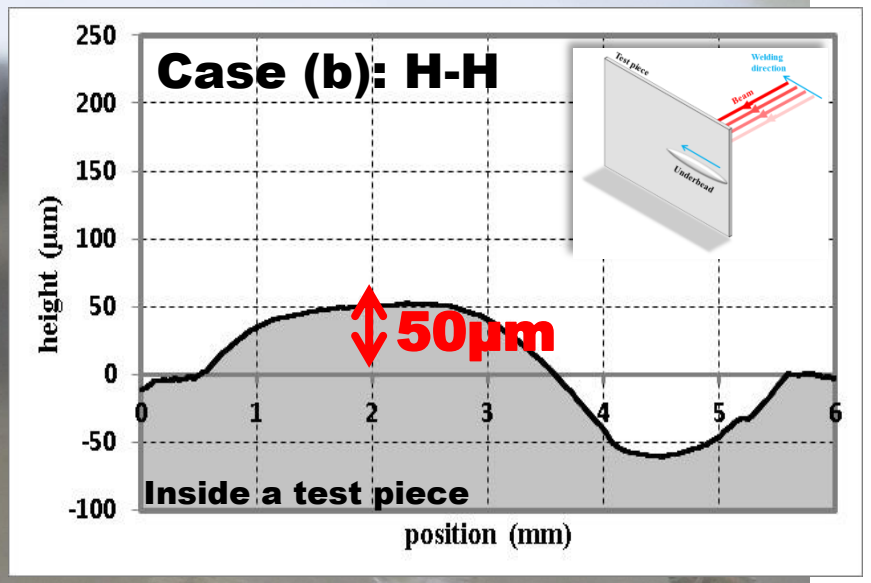
Case (d)
Horizontal gun direction and
Upward welding direction.

Cross section of an underbead

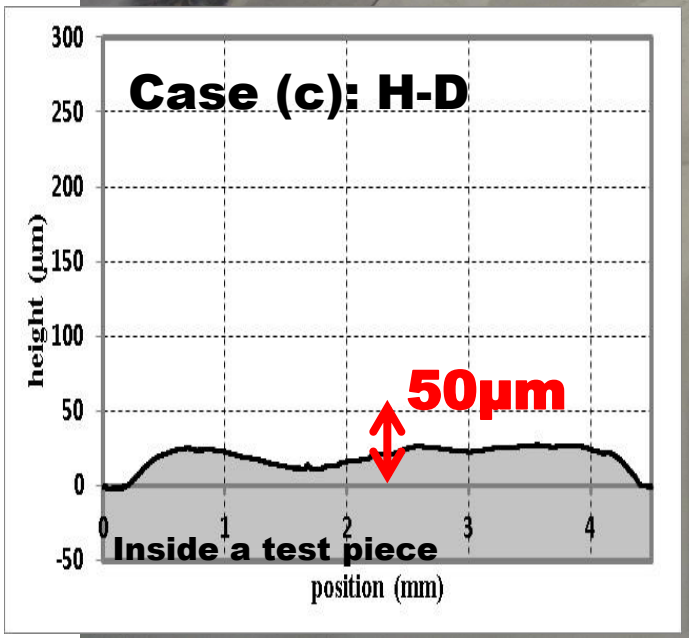


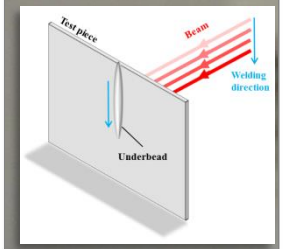
Underbead geometry

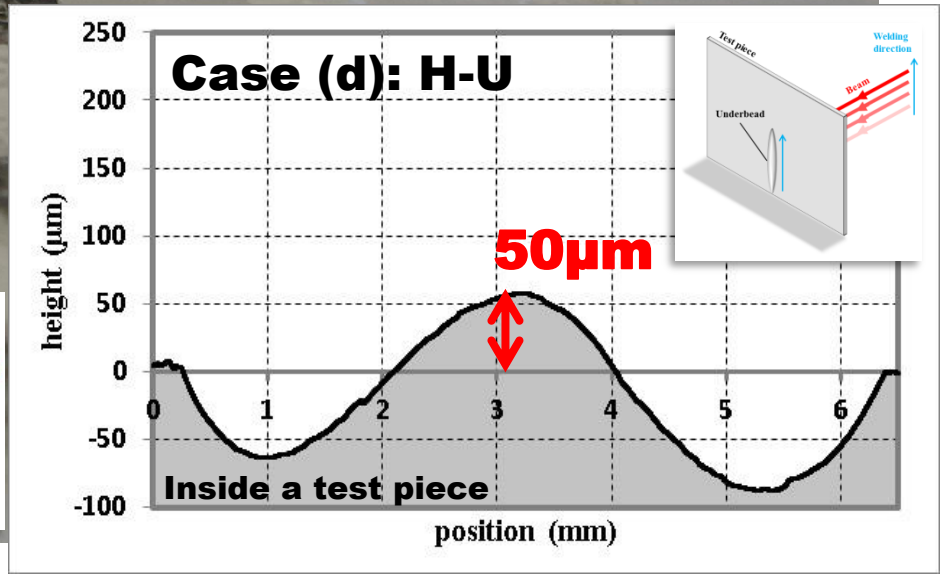




Gravity works for underbead geometry







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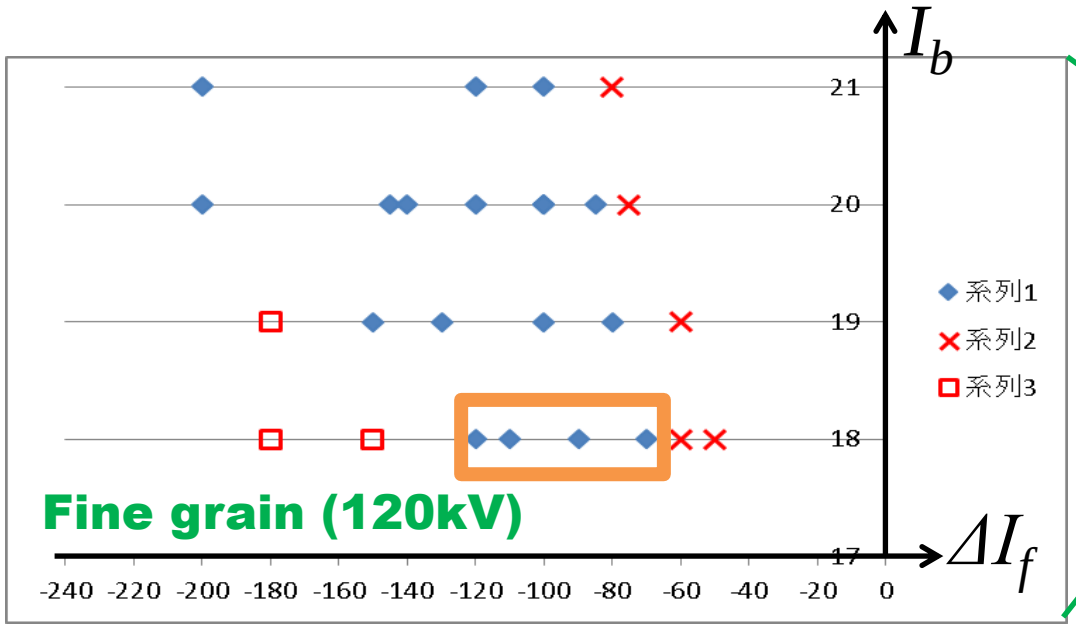
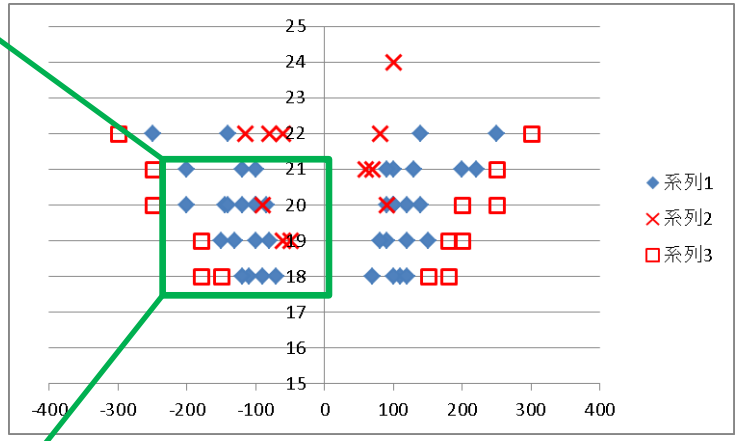
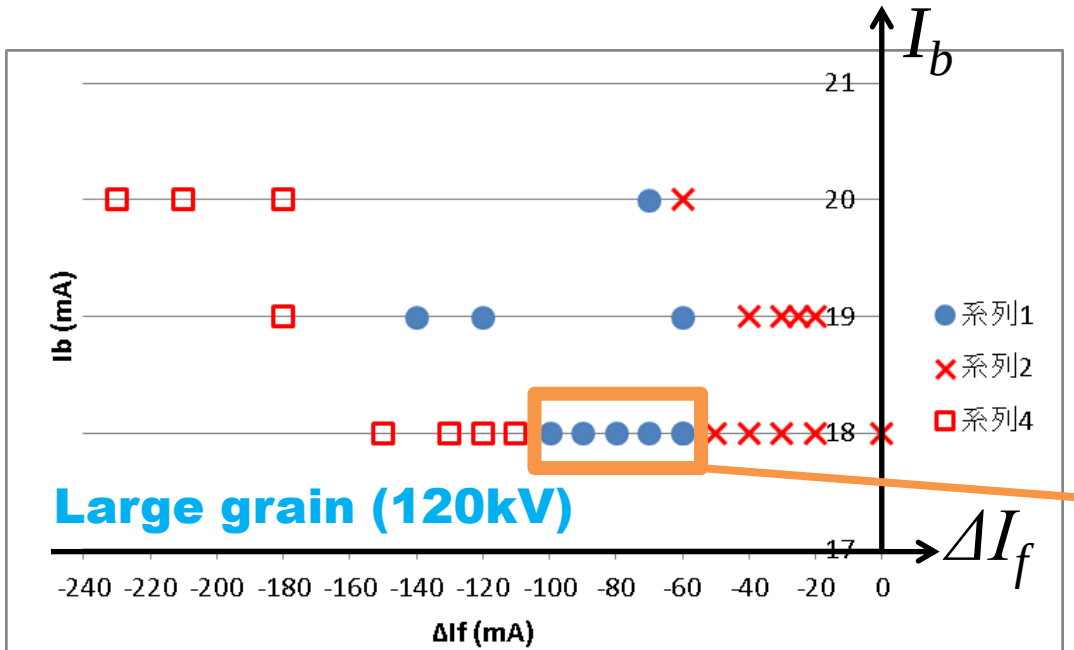
- **Comparison between LG/FG**
- **Dependence on groove surface thickness**

Good parameter regions for FG/LG, 120kV





Fine grain (120kV)



Parameter regions are similar for FG / LG.

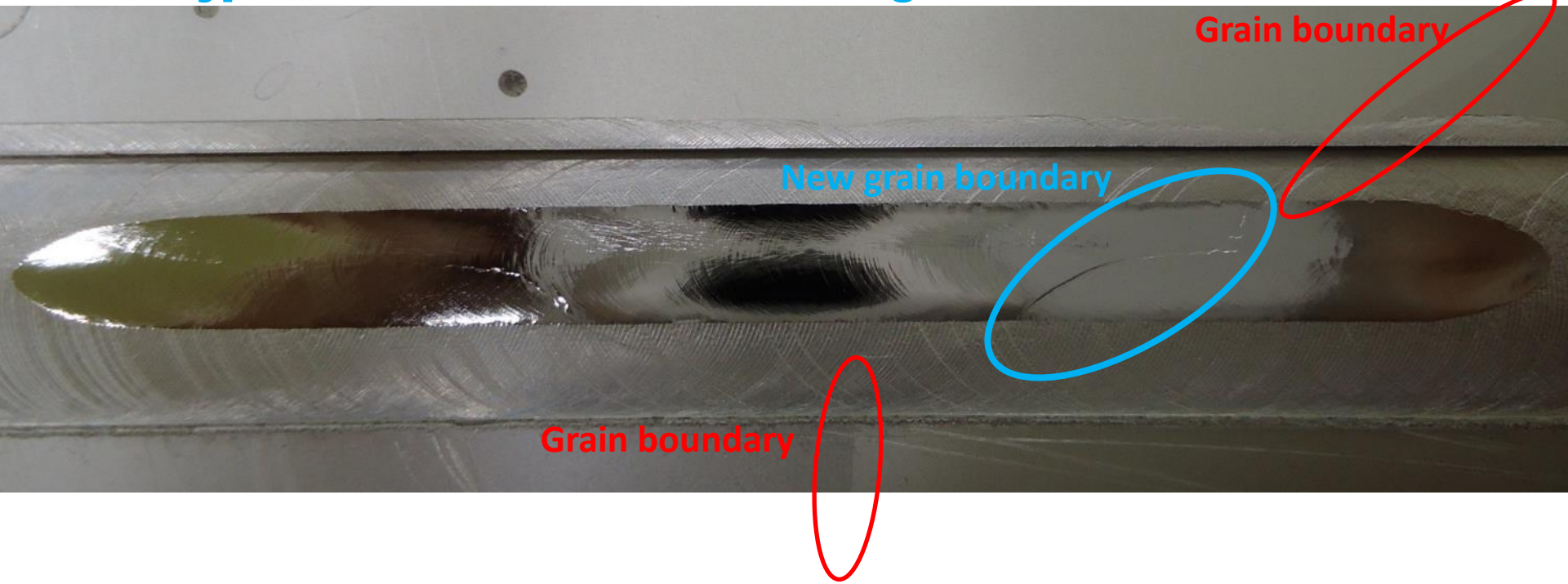
● : Good weld
× : Holes or spatters
□ : Narrow underbead

Selected parameter region

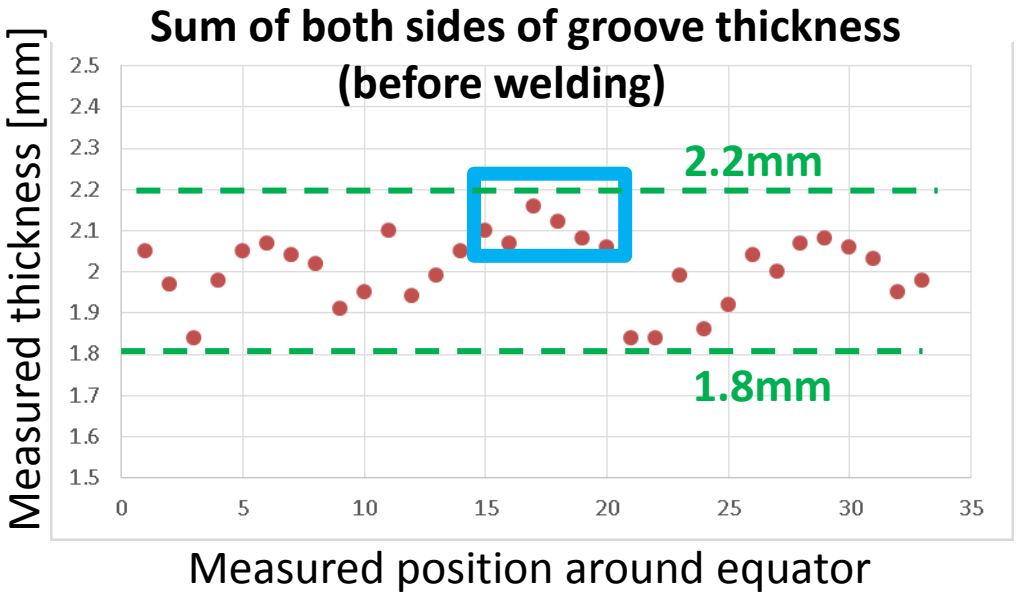
Comparison between FG / LG EBW bead

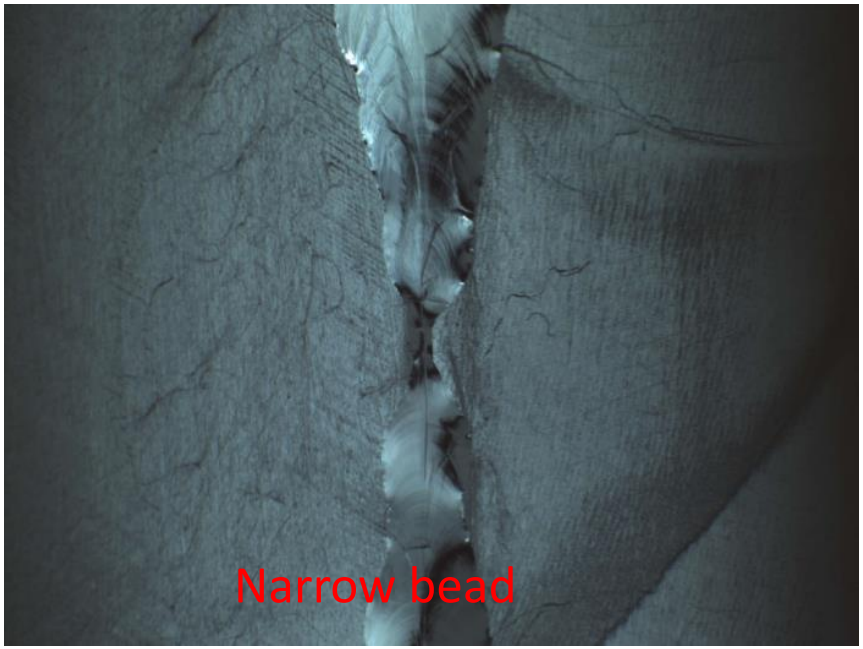
Typical underbead for FG.「V-type」structure can be seen.

Typical underbead for LG. Welding surface is smooth.



Dependence on groove surface thickness





Large grain cavity

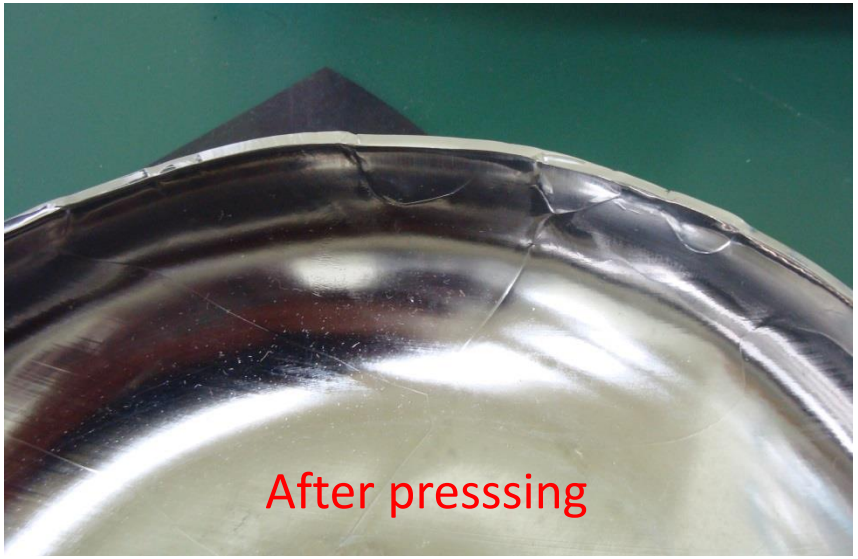
After pressing and trimming half cells, groove thickness were varied due to grain boundary

↓

Width of underbead becomes unstable.

Control of groove thickness is important.

This is same for FG. If not controlled, sometime make holes or unpenetrated beads.



Summary

(1) EBW optimization for fine grain Nb samples

- Good condition depend on beam power and defocusing, i.e. probably beam power density
- Geometry of EBW welding depend on the direction of beam / work

(2) EBW study for Large grain Nb samples/cells

- Good condition for FG / LG does not change much.
- Control of groove surface thickness is important

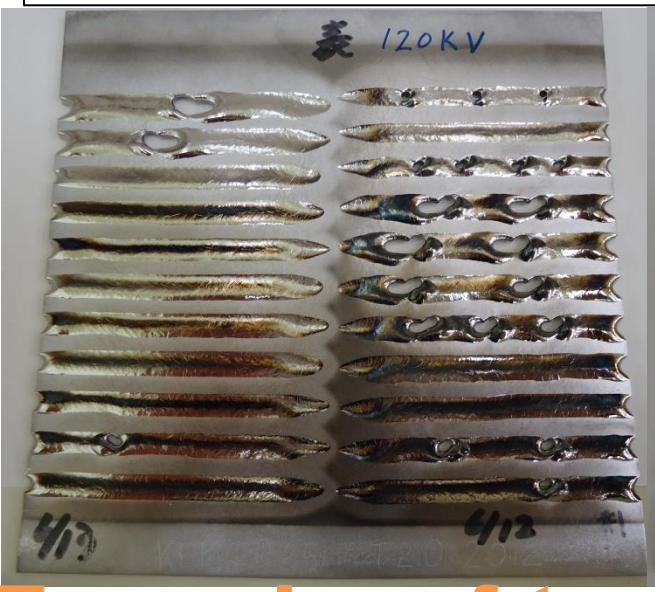
Discussion

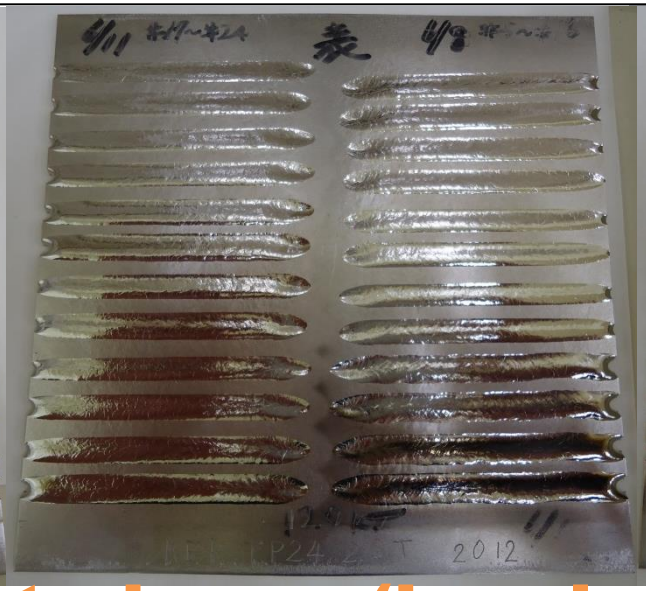
Which is the best EBW parameter and how do we evaluate?

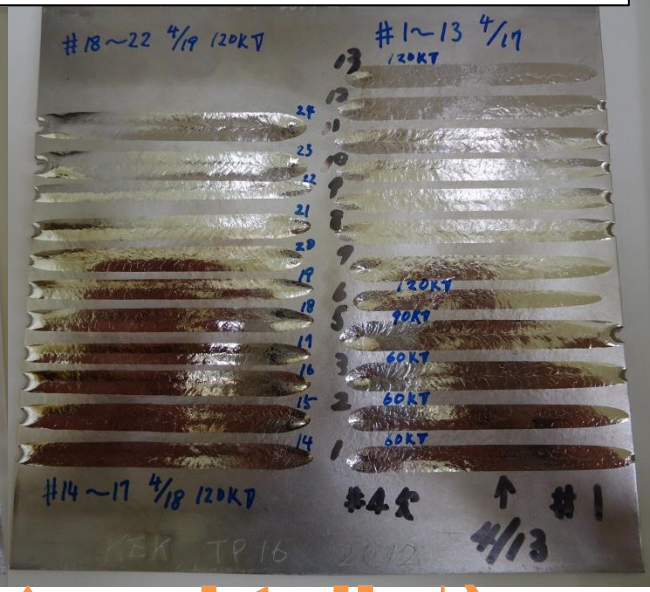
- At present, we try to find the welding bead which is as "smooth (flat)" and "stable" as possible.
- The parameter region we showed is the region where we can avoid apparent failure. → minimum requirement
- But, normally, cavity performance are limited by defects, such as pits or contamination.
- Even the case of not smooth welding / not stable welding, cavity field can often reach to theoretical limitation.
- At least, welding geometry, i.e. "smooth (flat)" weld, seems not to be important. → Is this correct??
- From RF point of views, weld bead should be evaluated from the number / size of defects. → But… how should we do?
- Is there any correlation between EBW conditions and number of defects? → **Final requirement "bead with no defects"**
- Cleanness of weld groove is more important?
- How about iris? Mostly, pits do not affect cavity performances. What is required?

Backup slide

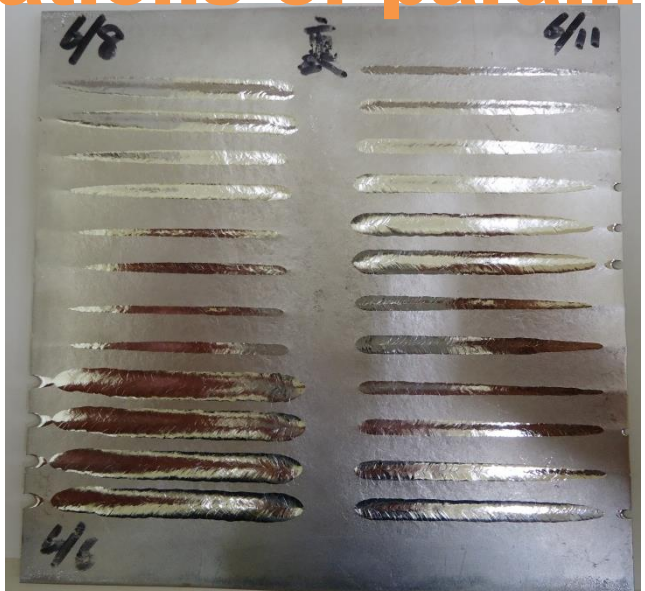
Experiment (cont.)

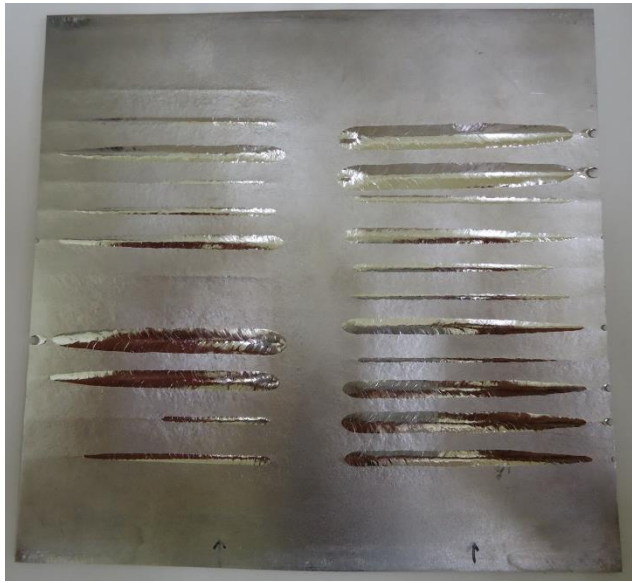




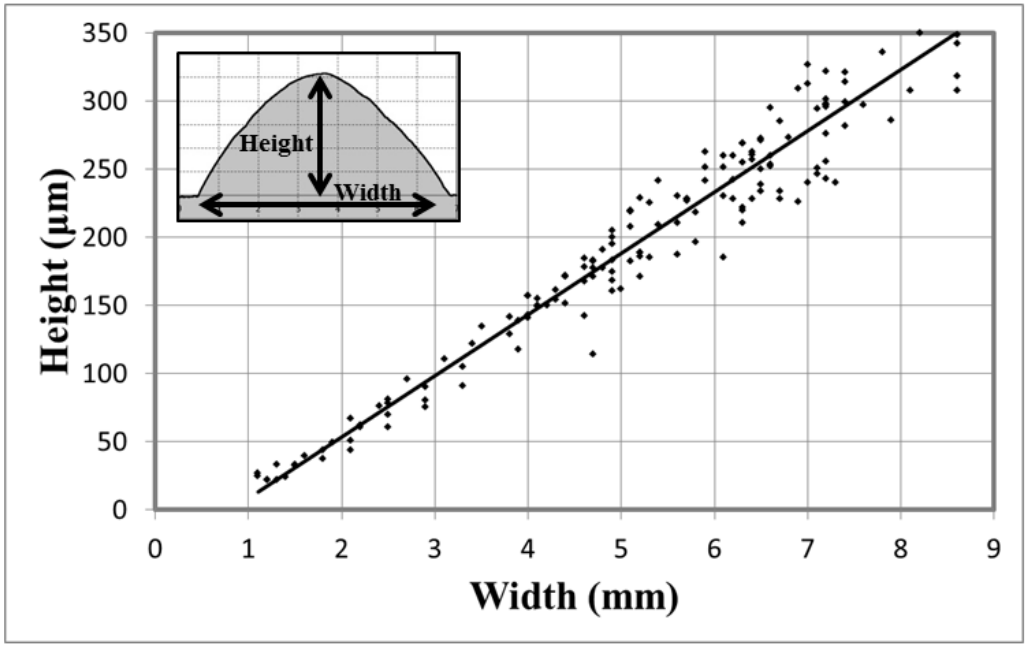


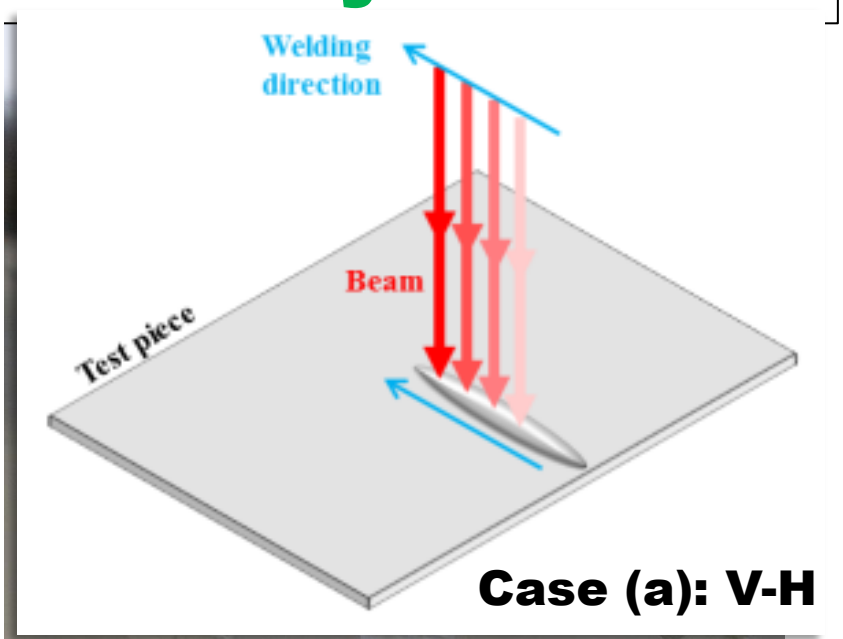
Examples of test pieces (heads↑ and tails↓).
Various combinations of parameters were tried



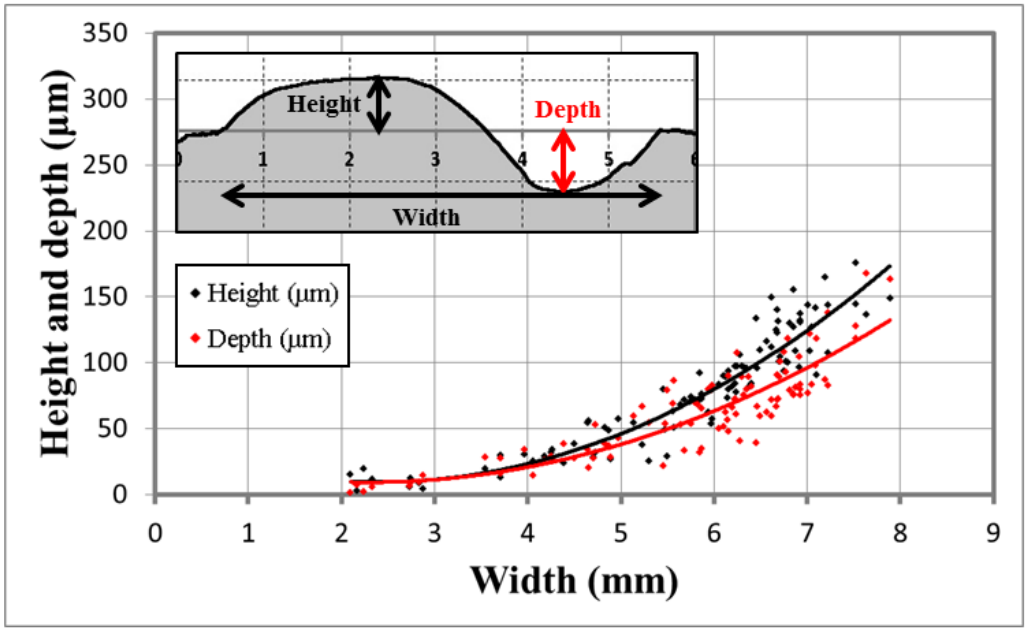


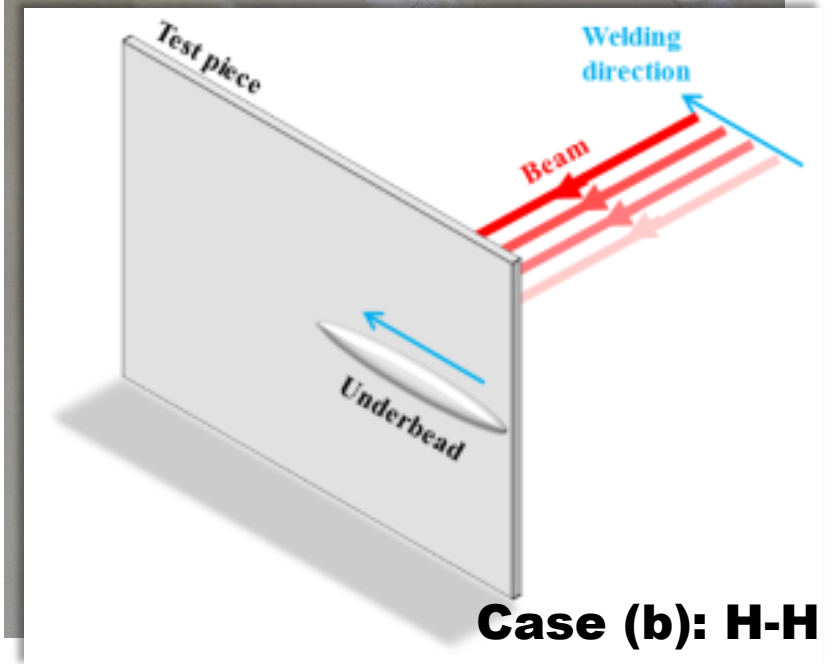
Underbead geometry





Case (a): V-H





Case (b): H-H