

# In-situ Strain Measurement During Arc Welding Process Using Digital Image Correlation



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## Introduction

Digital image correlation (DIC) technique is a non-contact method that can measure the full-field displacement and strain on the material surface. In-site DIC strain measurement during the arc welding procedure remains challenge.

### Problems

- Intense welding arc light interference
- Speckle pattern is vulnerable to the welding high temperature
- Temperature variation, electromagnetic noise and radiation is increased with decreasing distance to the weld
- Very sensitive to light sources changes.

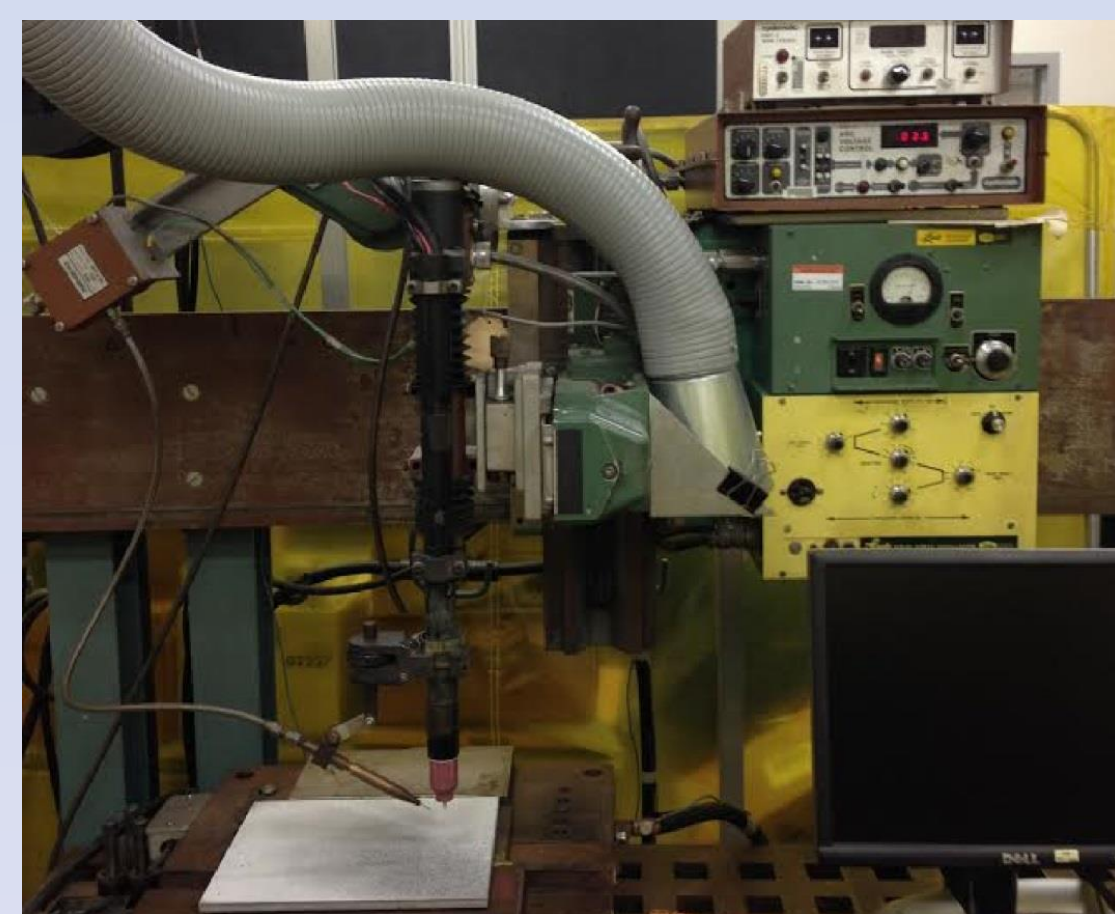
## Experiment Variables

- |                            |                     |                                |
|----------------------------|---------------------|--------------------------------|
| Material<br>6mm SS304      | Voltage<br>12 V     | Wire feed speed<br>20 inch/min |
| Wire:<br>0.045 inch ER308L | Current<br>130~160A | Travel speed<br>12 inch/min    |

### Arc Welding Equipment



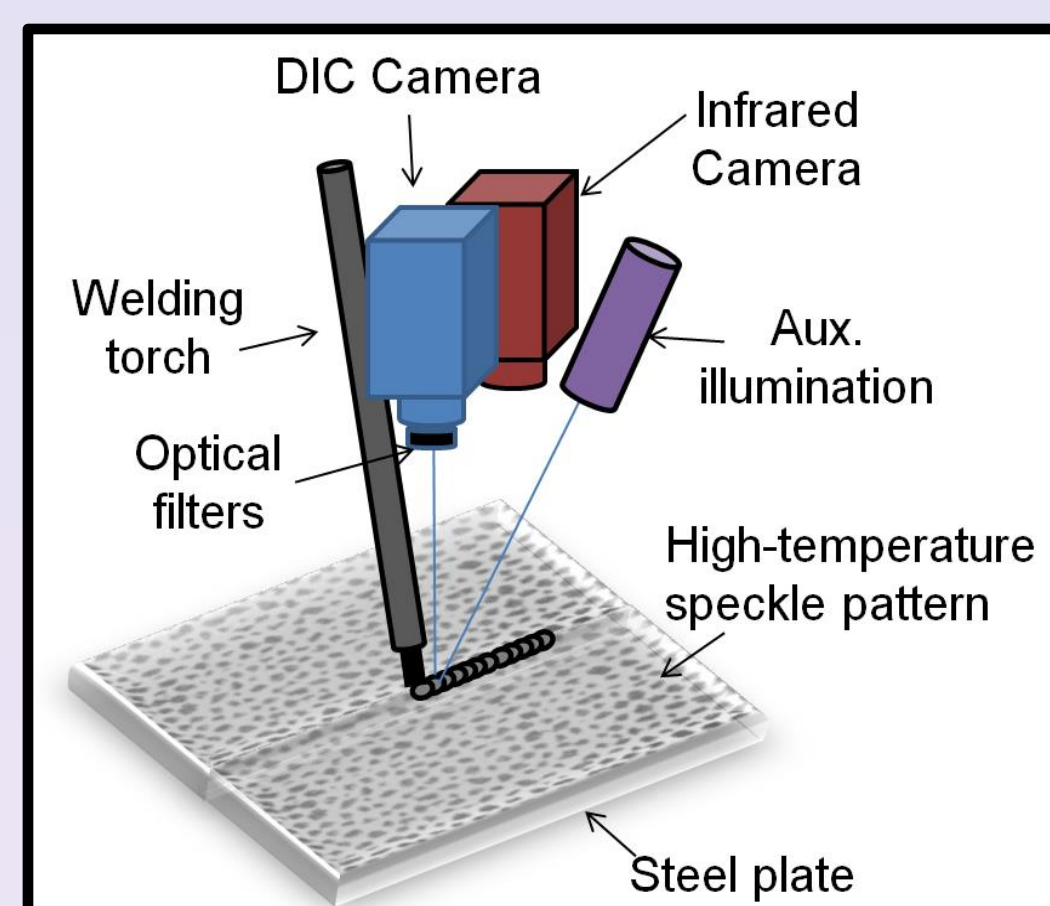
Miller TIG machine and controller



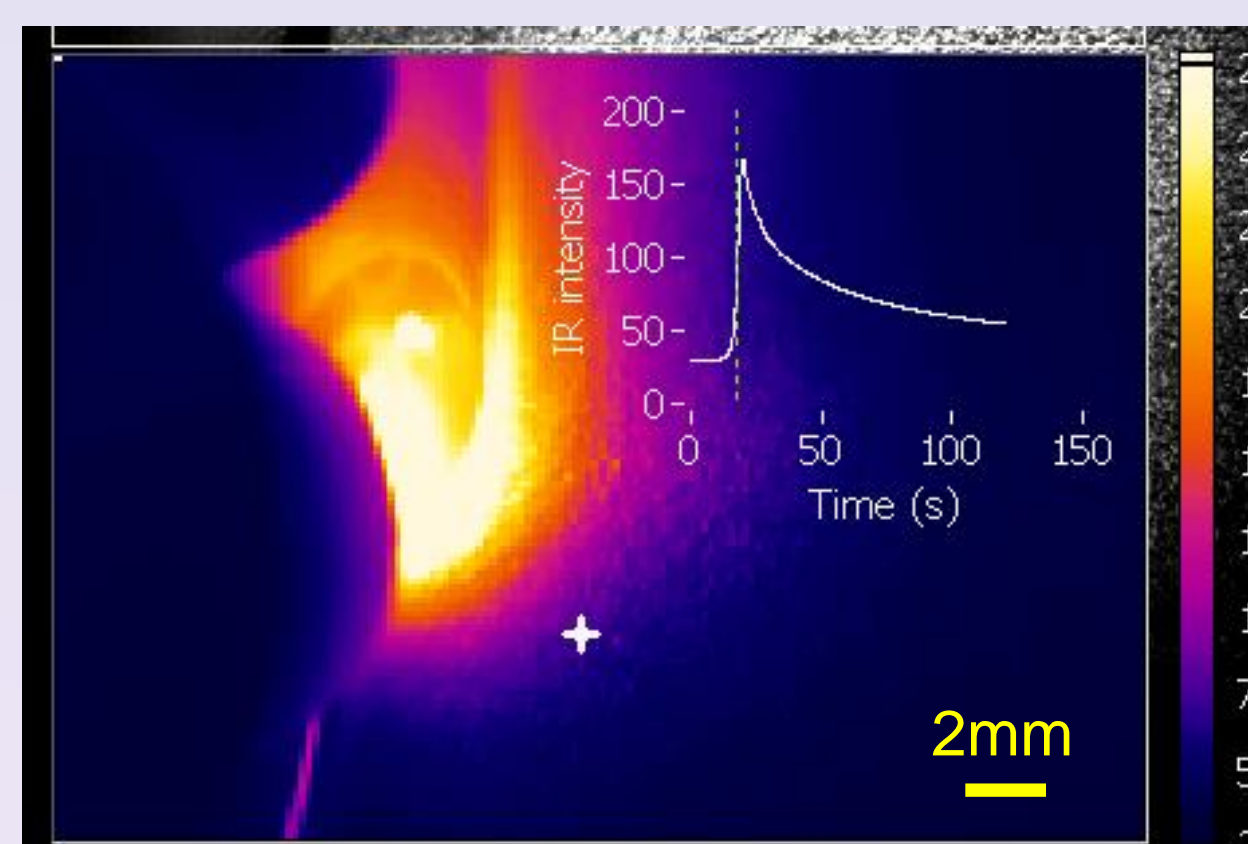
## Measurement

### Improvement

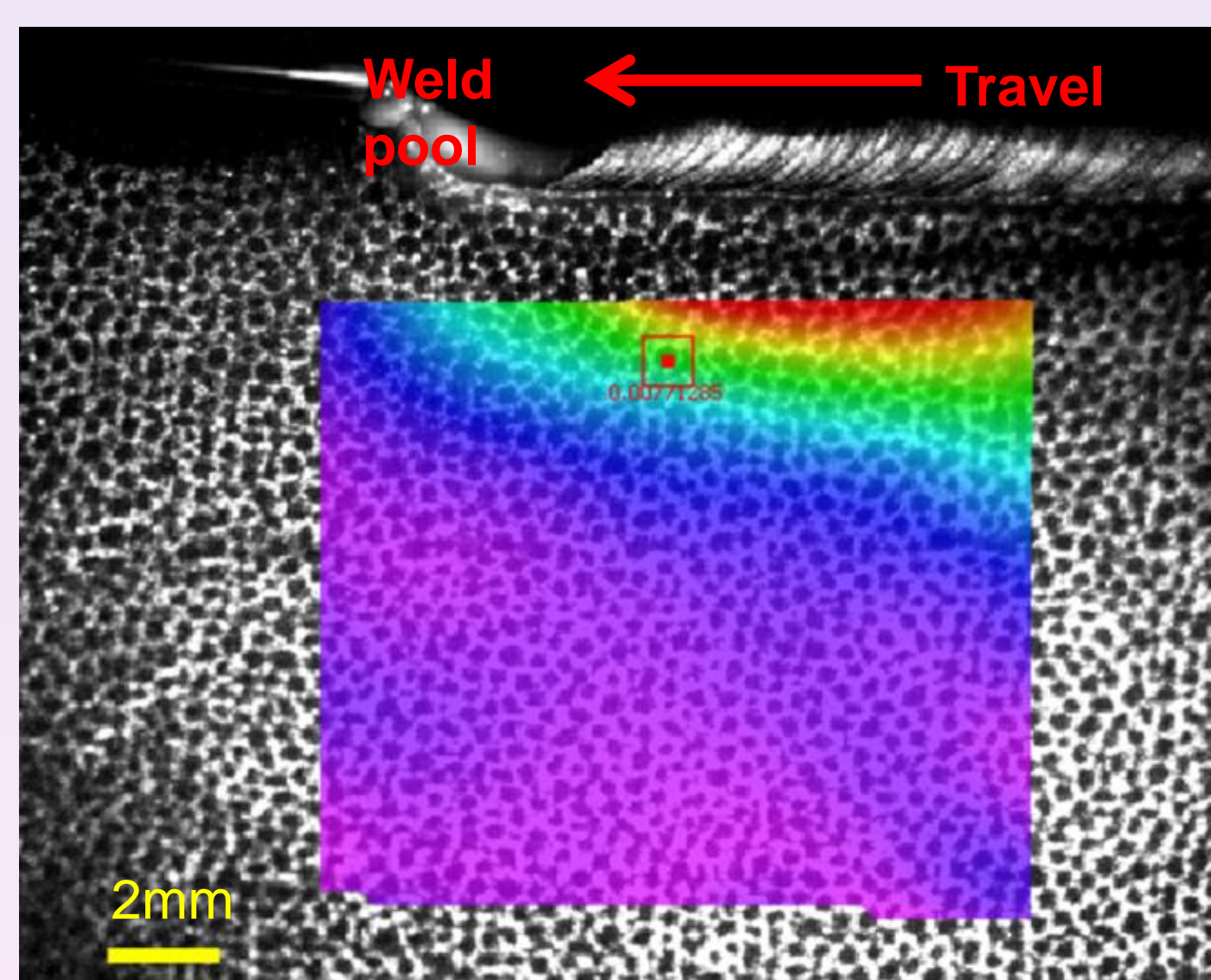
- Integrated illumination and filtering system to suppress the influence of intense arc light
- Special prepared high temperature sustainable speckle patterns
- Integrated infrared camera to measure the real time temperature distribution field of the welding area



New arc welding inspect system



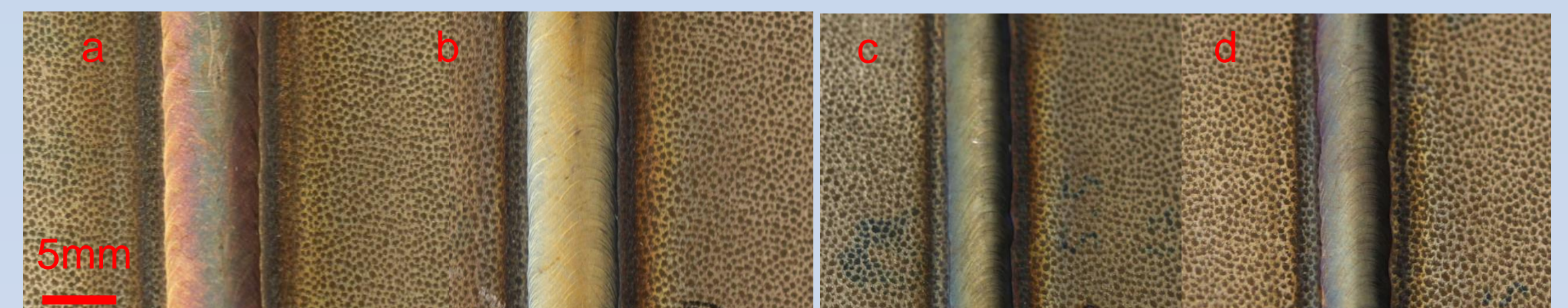
Real time temperature field monitoring using infrared camera (IR)



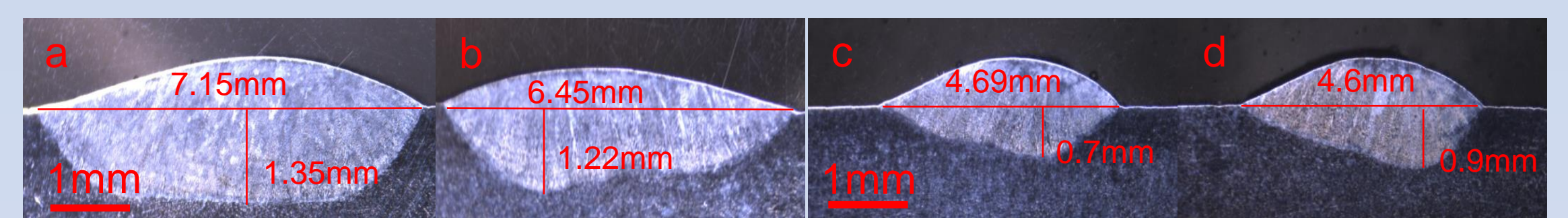
Strain measurement and monitoring during arc welding from DIC camera

## Result

- Four groups of bead on plate welding experiment are conducted under different current.
- Oxidation will change the speckle pattern at 2mm away from the weld, the closest measureable distance by DIC is 2.5 mm to the fusion line.

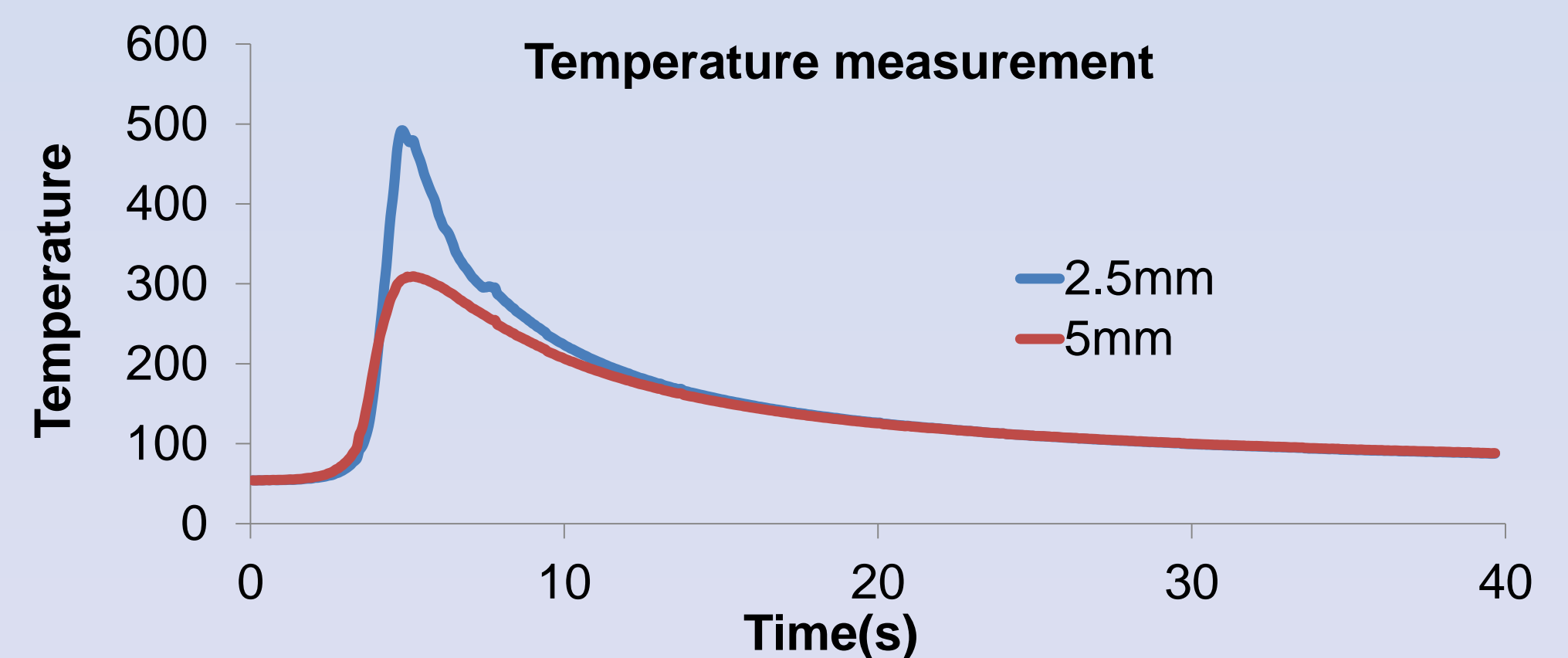


Top view of weld (a)(b) under 160A current, (c)(d) under 130A current

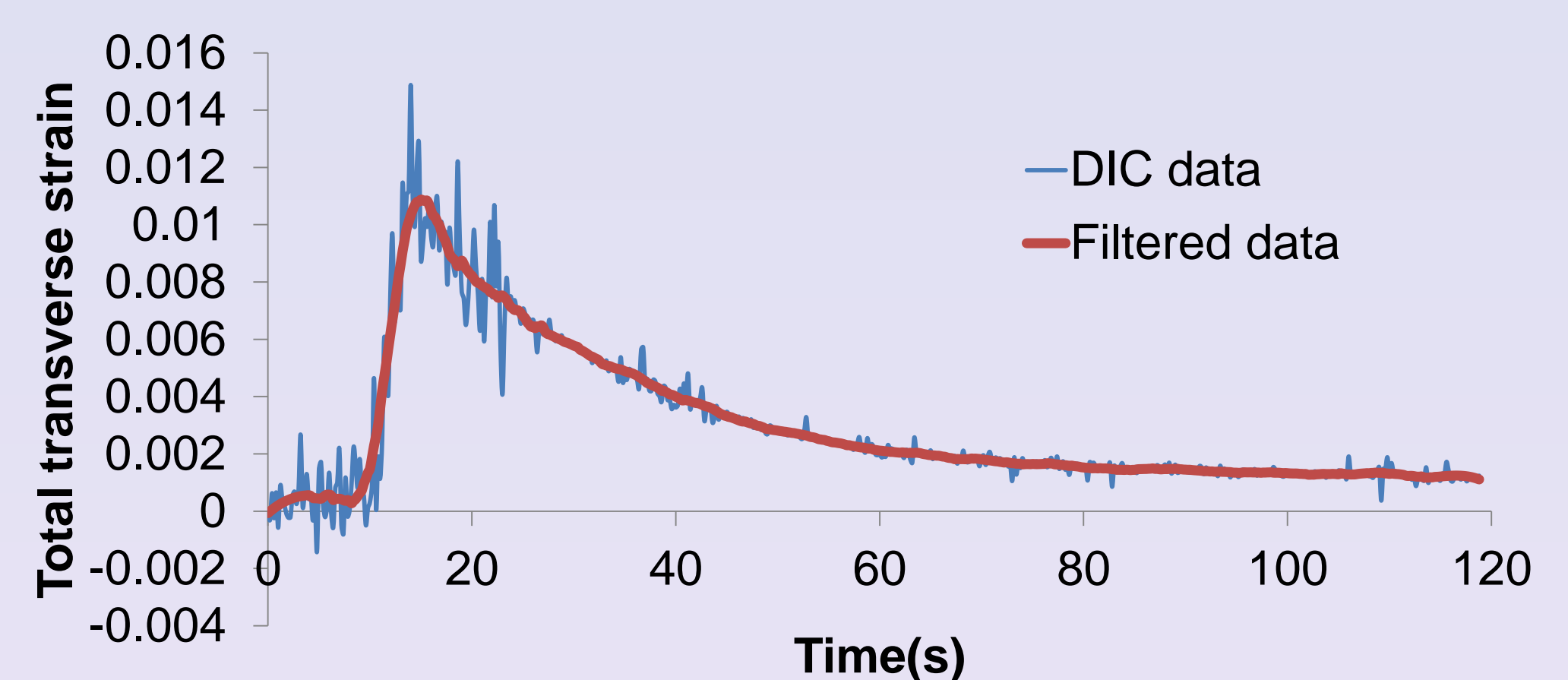


Cross-section of weld (a)(b) under 160A current, (c)(d) under 130A current

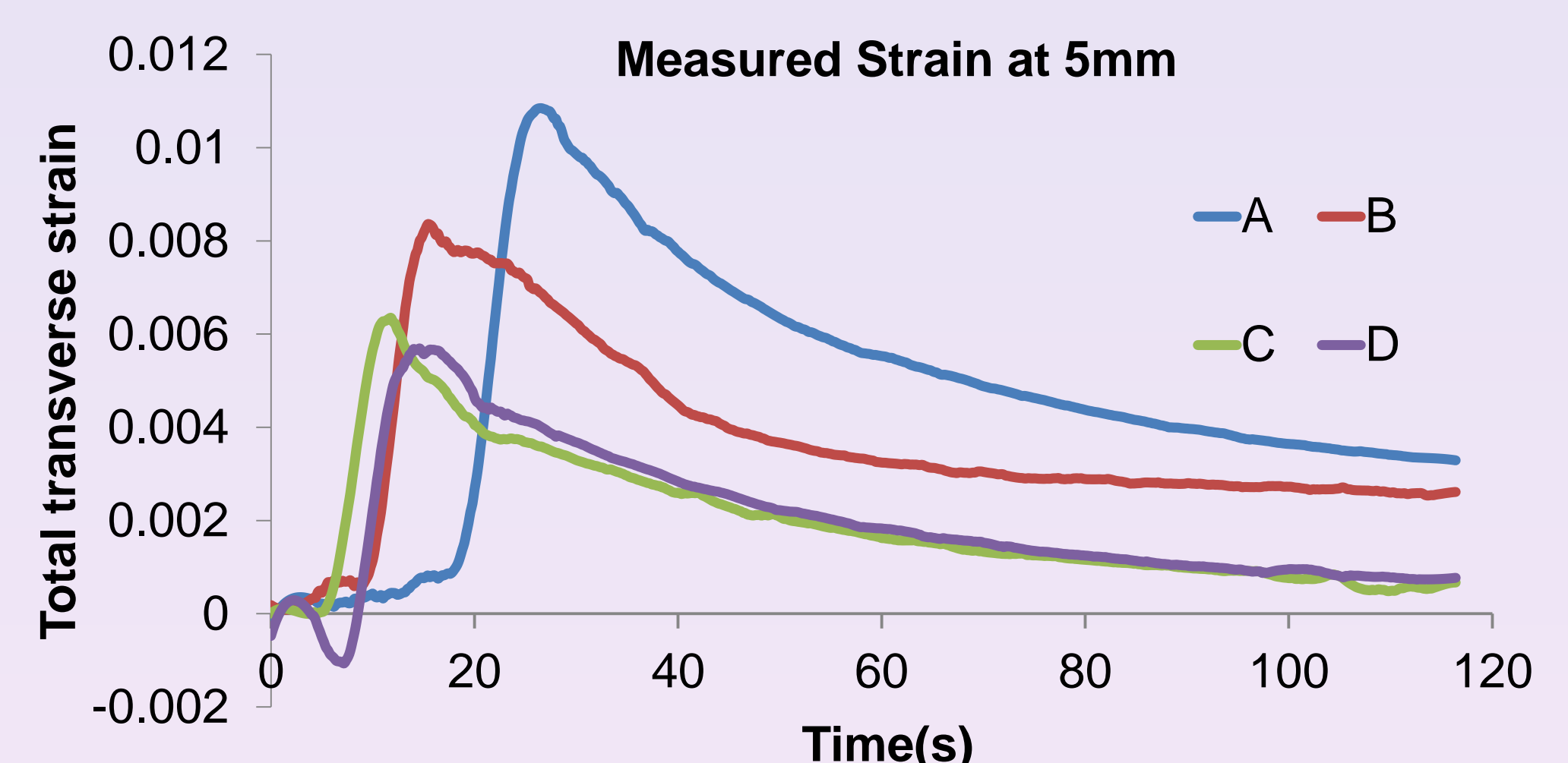
- The calculated temperature at 2.5mm close to the weld reach  $500 \pm 10^\circ\text{C}$ . Two thermal couples (TC) were soldered on the surface for temperature calibration.



- Air turbulence near the hot weld surface can cause shimmering and distortion of DIC images, hence, resulting in noises on calculated strain evolution curves as shown in the figure below. Such noises can be reduced by low-pass filtering.



Strain measurement at 2.5mm to the weld



Strain measured at same distance to the weld, (a)(b) under 160A current, (c)(d) under 130A current

## Conclusion

The experiment result shows that our measuring system is feasible for in-situ DIC strain measurement adjacent to the weld line in the front side of steel plate.

## Acknowledge

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