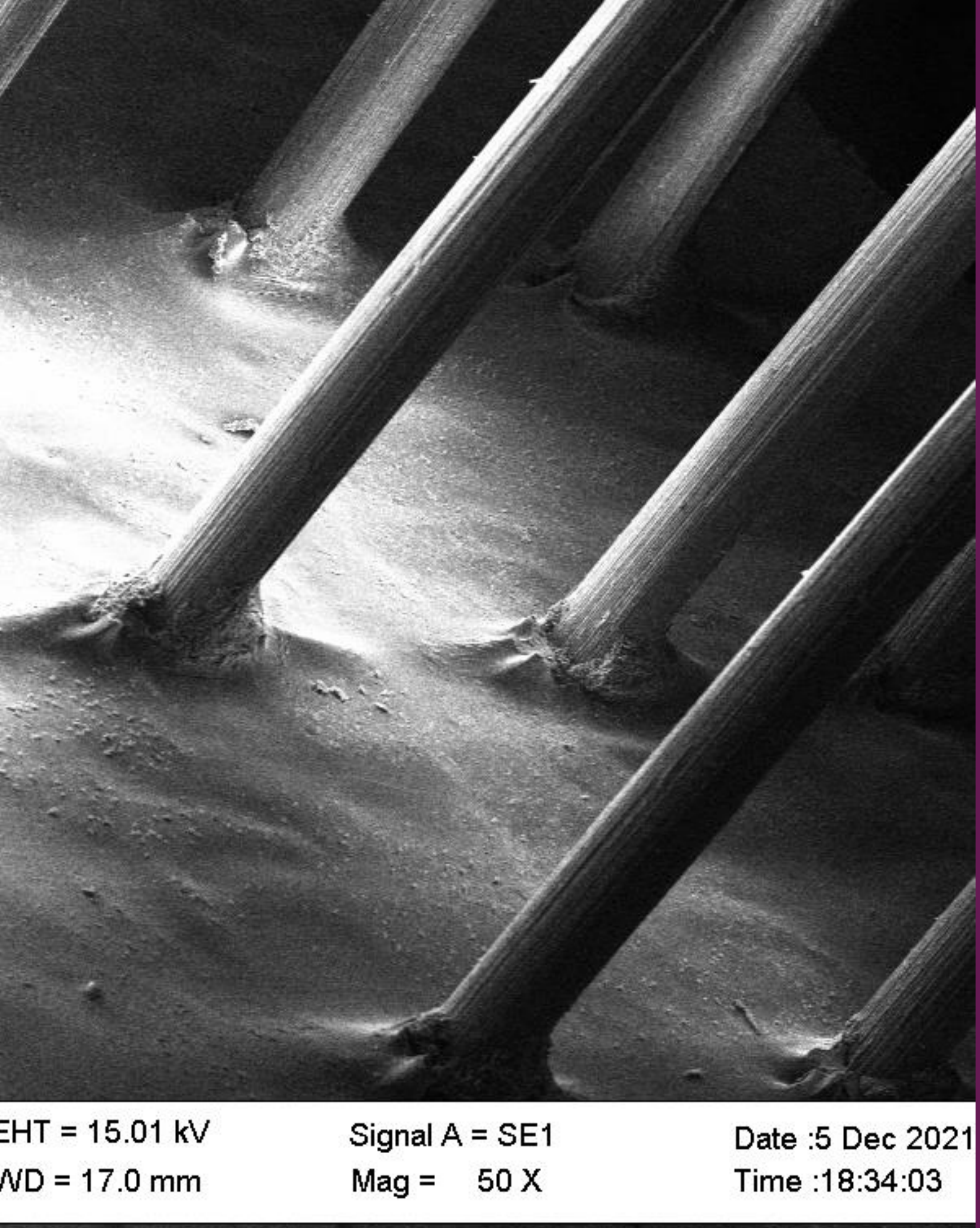

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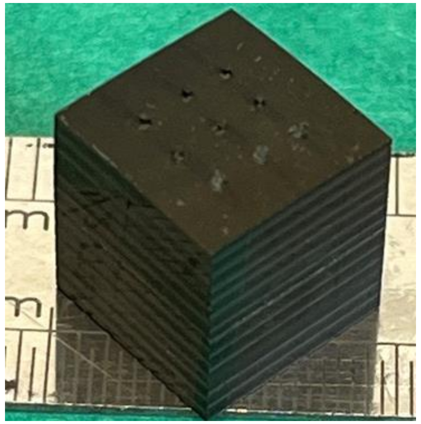
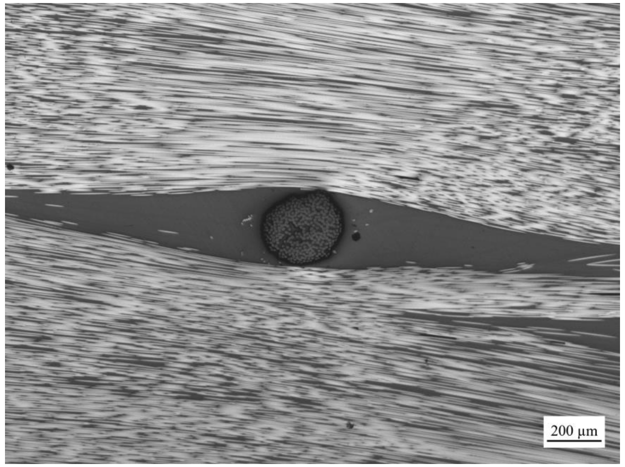
AN EXPERIMENTAL STUDY OF THE RATE DEPENDENT BEHAVIOUR OF THROUGH-THICKNESS REINFORCEMENT IN Z-PINNED CFRP LAMINATES

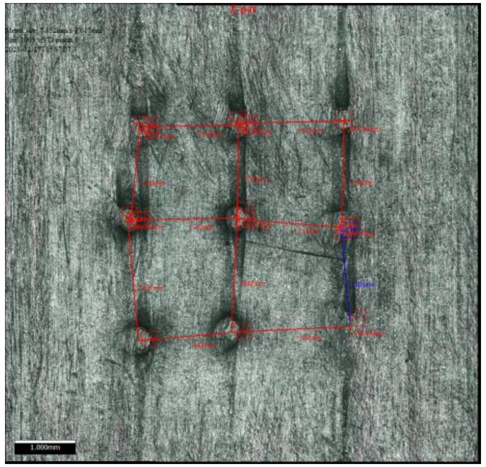
Huifang Liu

Specimen

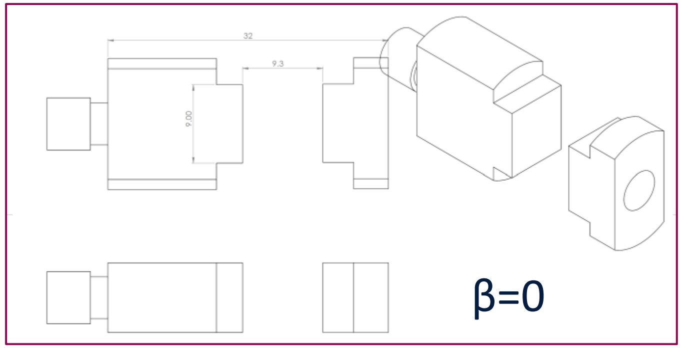
- Z-pin
  - Method: Direct Insertion (DI)
  - Material: BMI/T300
  - Diameter: 0.28mm
- Laminate
  - Thickness: 4.6mm//PTFE//4.6mm
  - Pin matrix: 3*3, 2% areal density

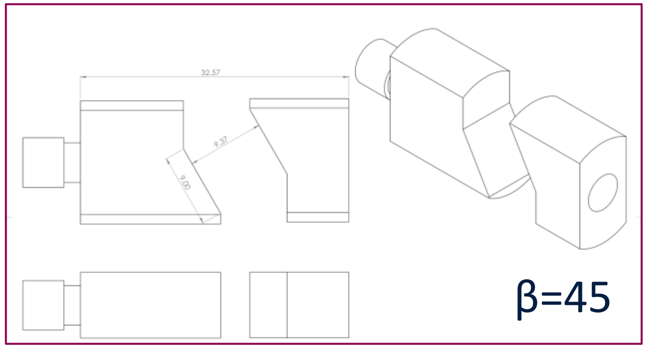


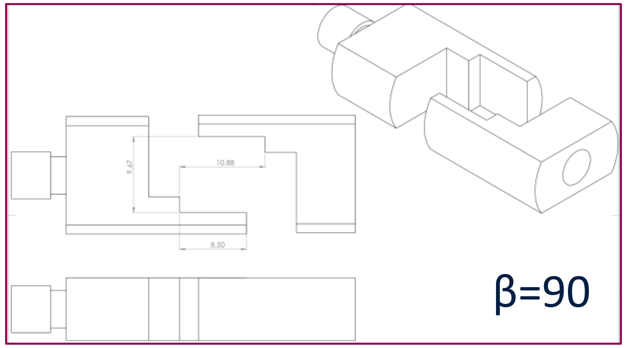


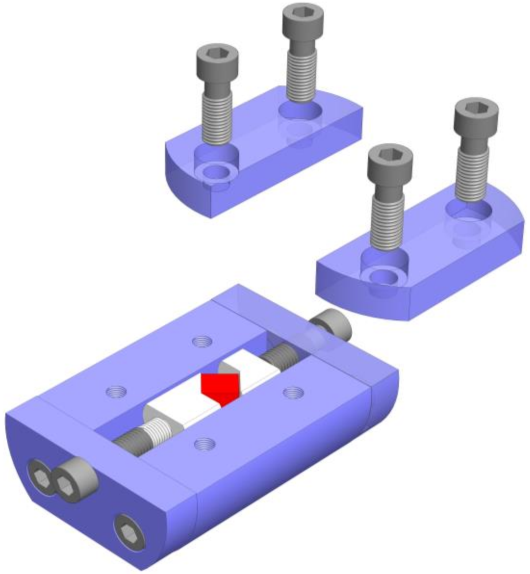


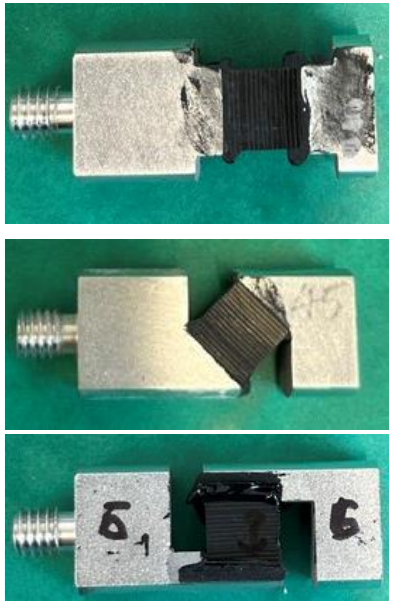
Experiment

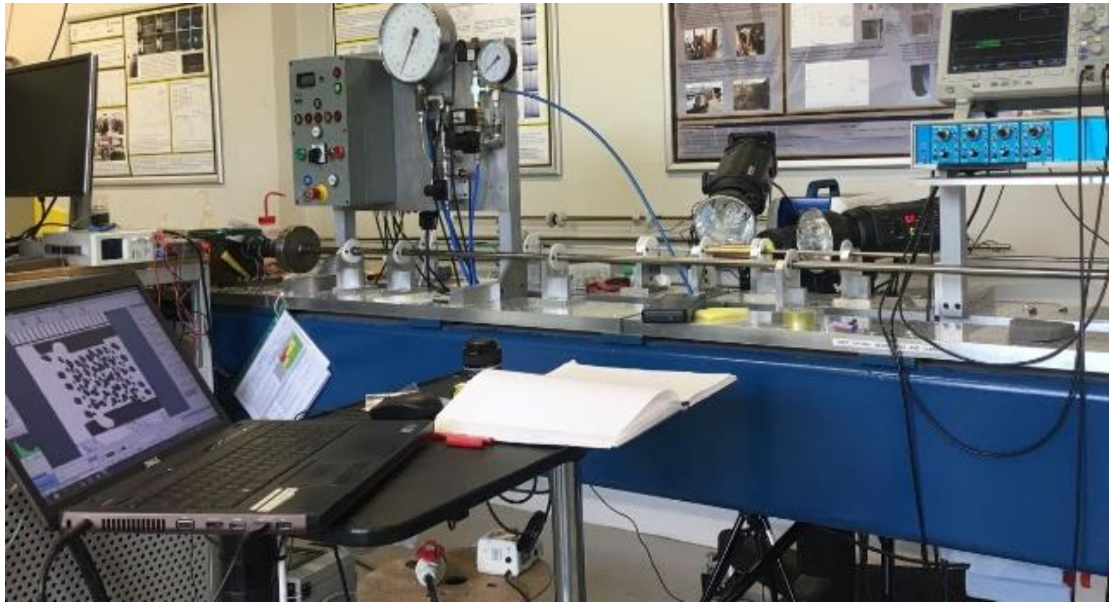








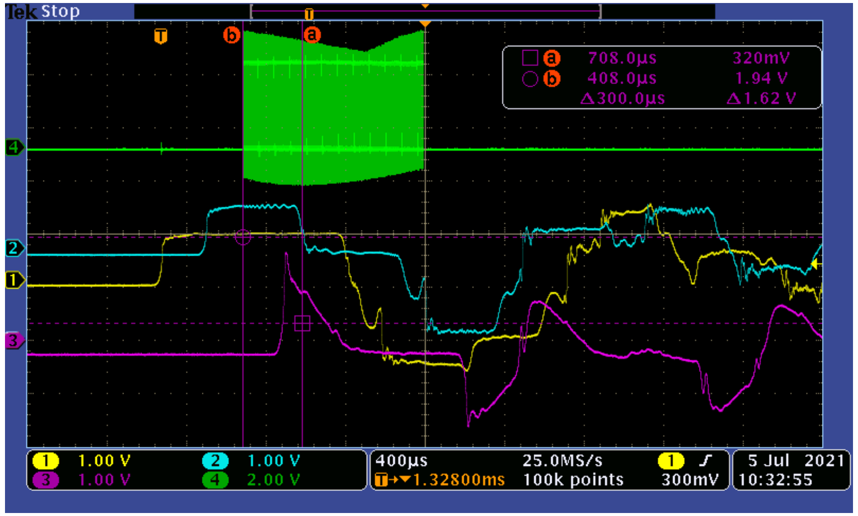




- Incident Bar: Titanium bar, D = 10mm
- Transmission Bar: Aluminum tube, OD = 6mm, ID = 4mm

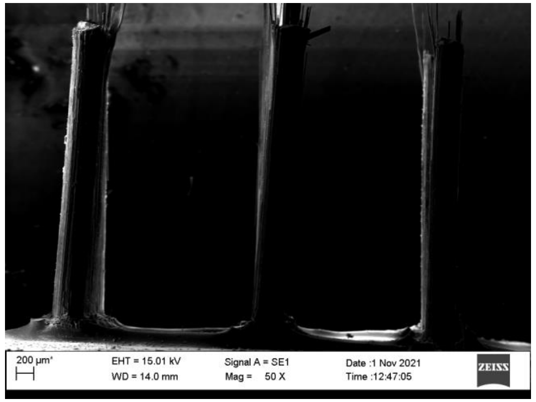
Experiment

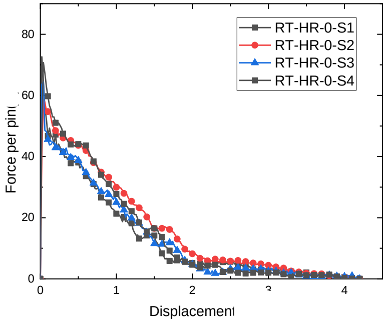
- High-speed camera: Kirana
- Displacement: DIC
- Force: Strain gauge on the bar

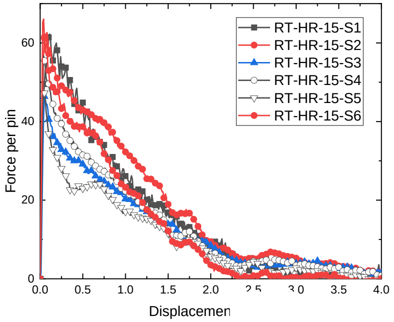


Overall results

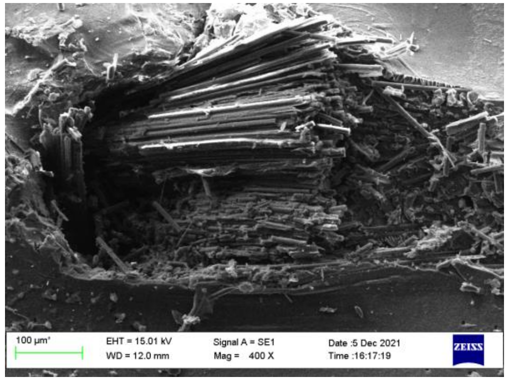
Pull-out failure

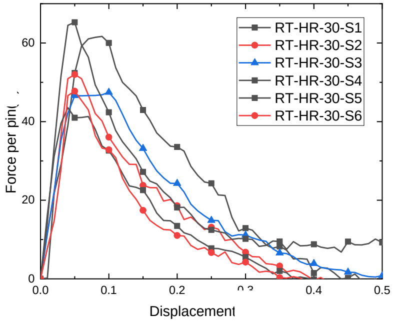


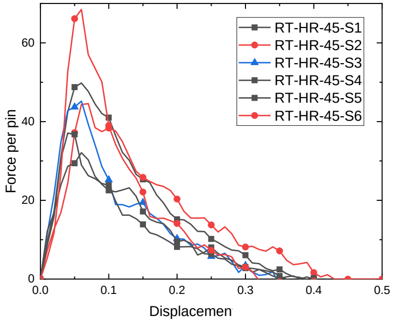


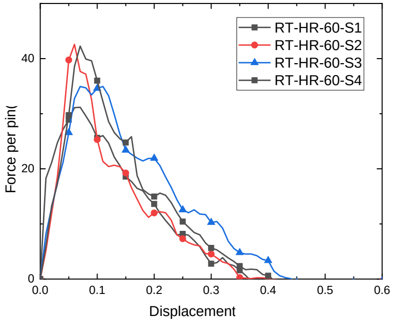


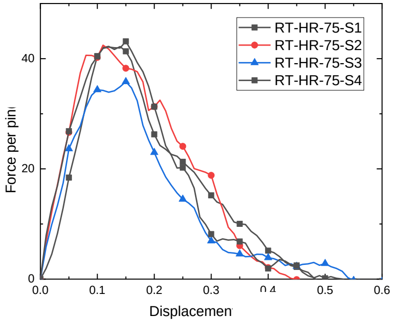
Z-pin breakage

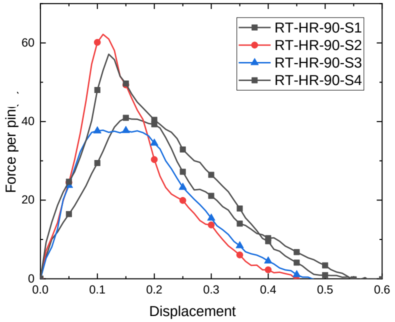




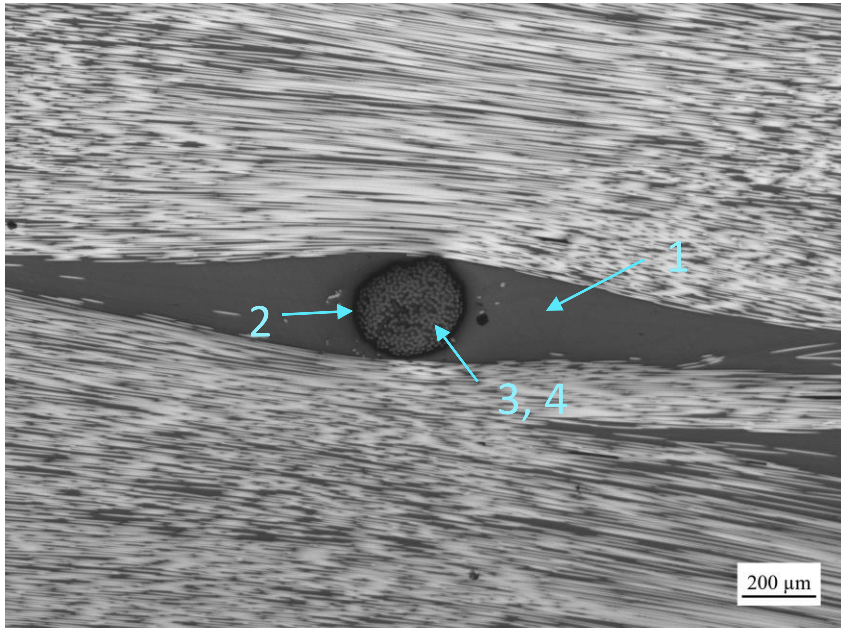


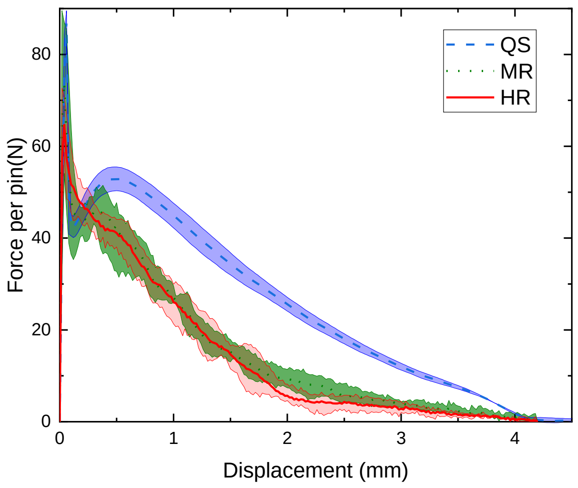


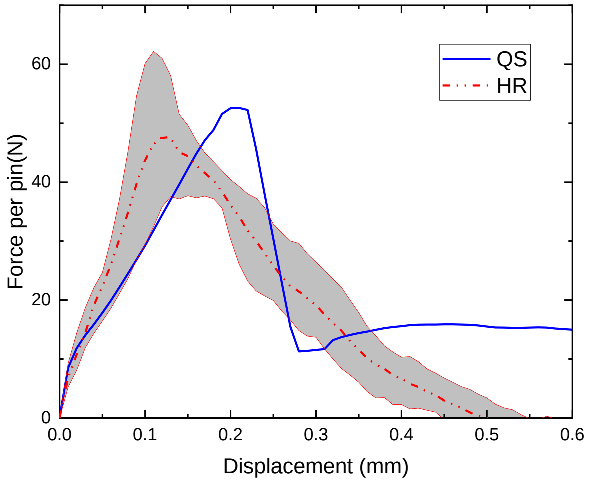


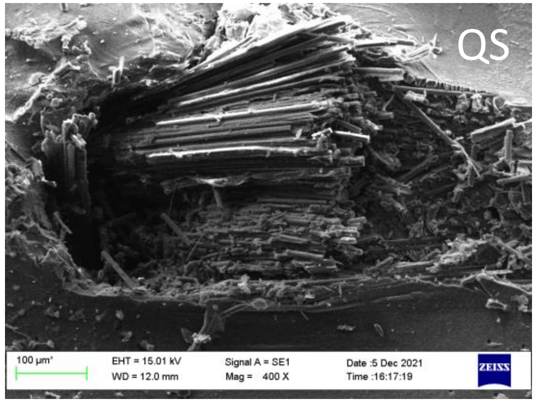


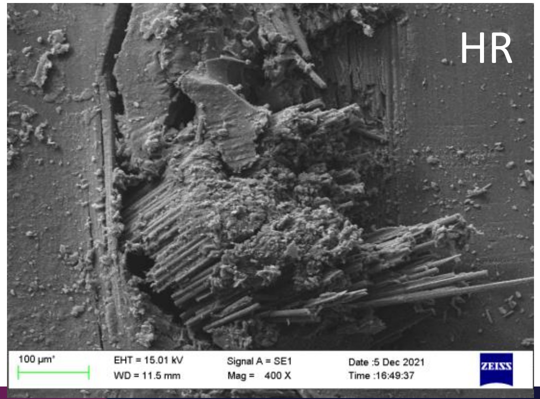
Loading rate effect





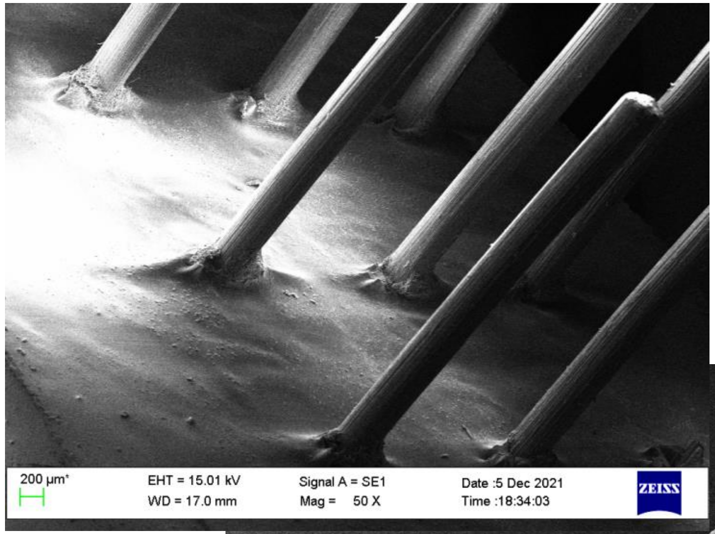


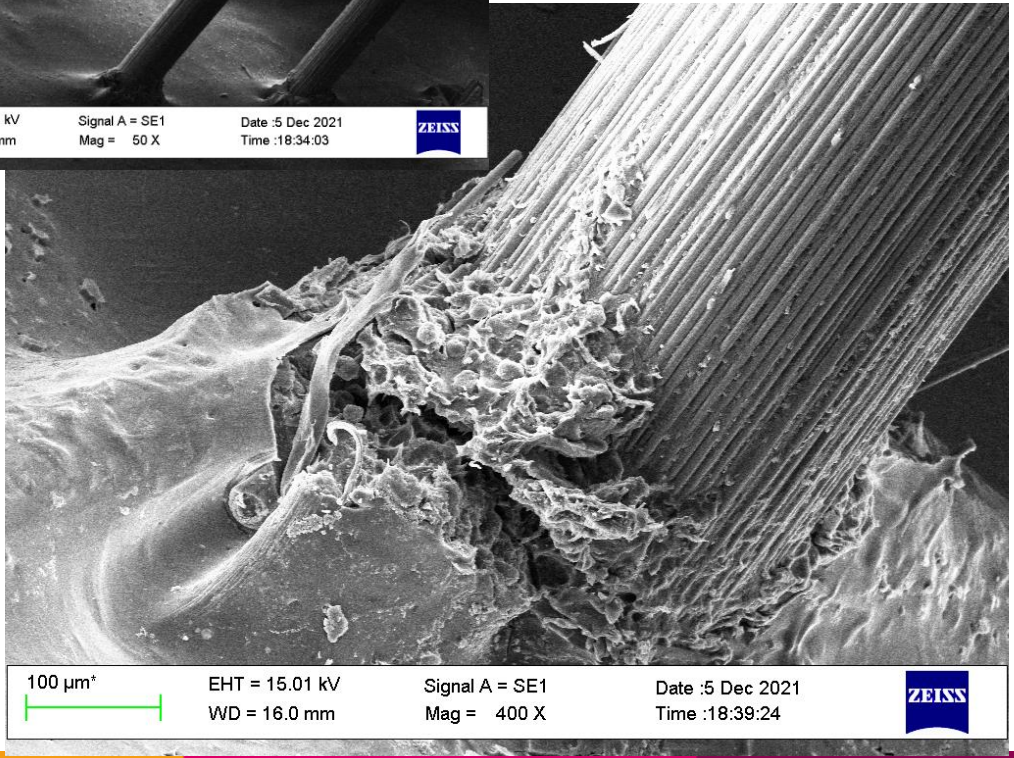




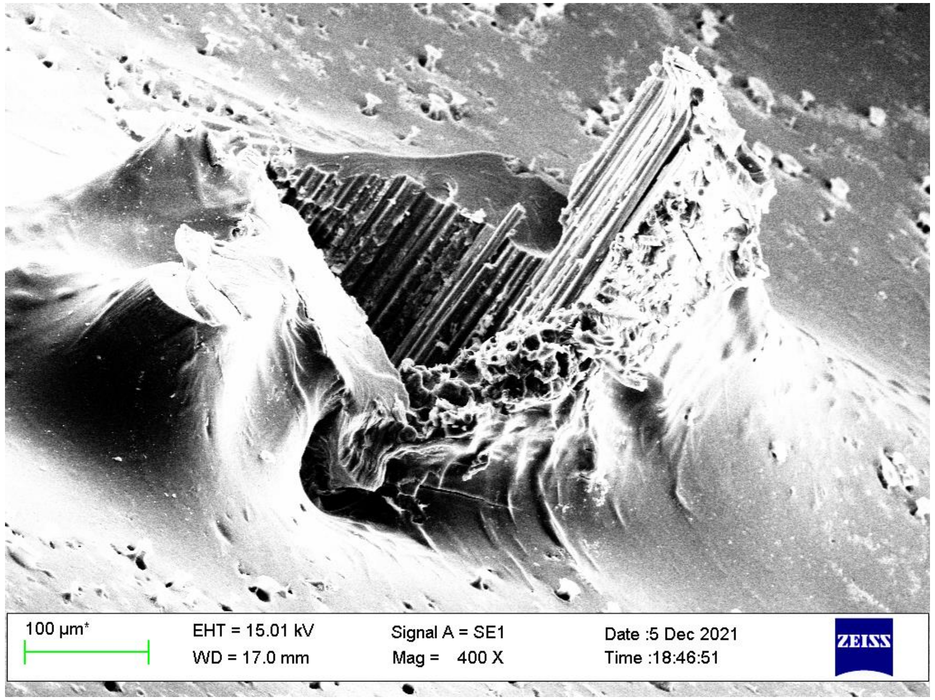
1. Resin failure
2. Interface between Z-pin and laminate
3. Debonding between fibre and BMI resin in Z-pin
4. Fibre breakage in Z-pin

Loading rate effect





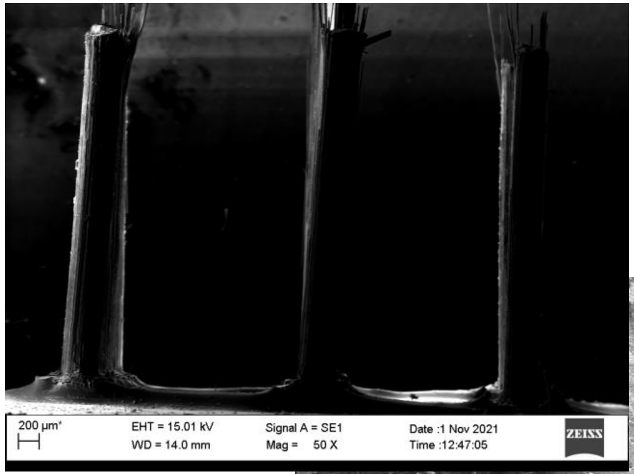
QS

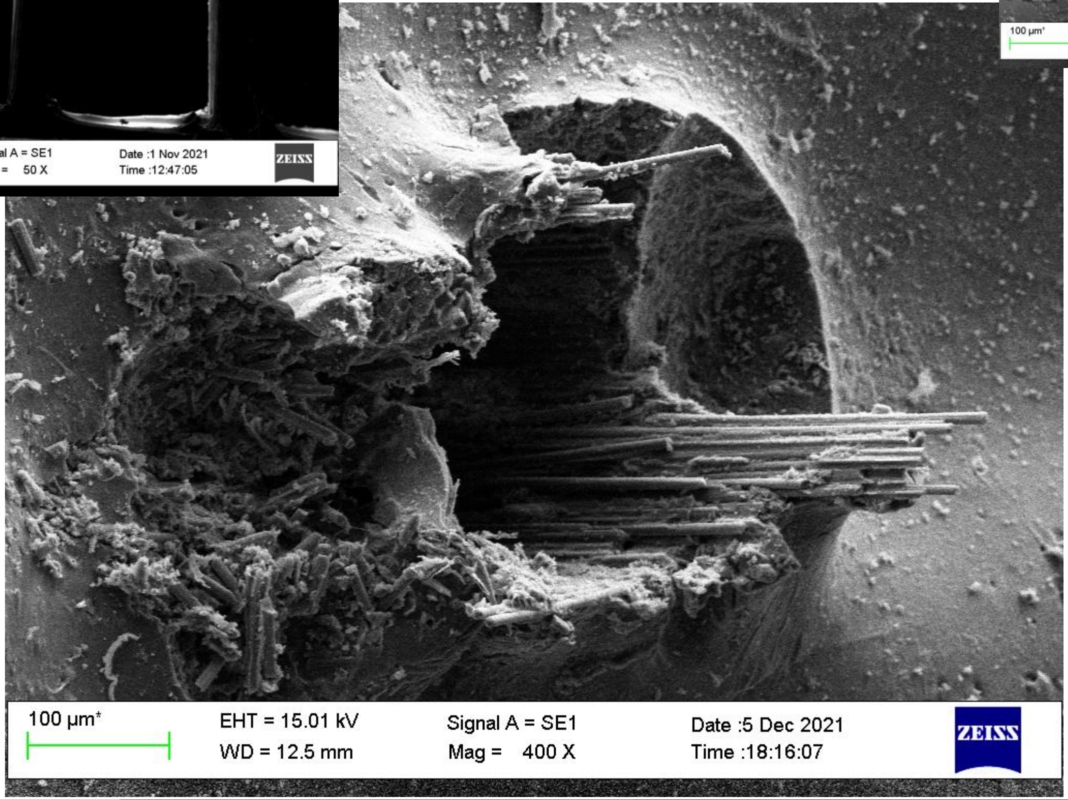


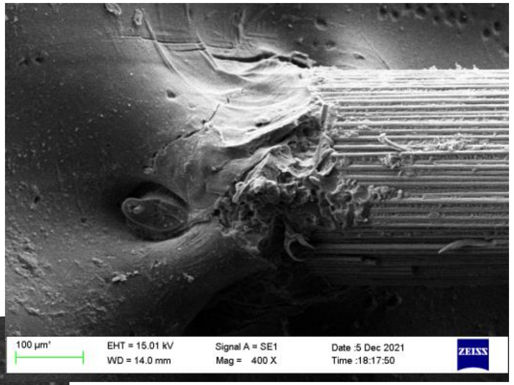
- Debonding between BMI resin and T300 fibre in Z-pin

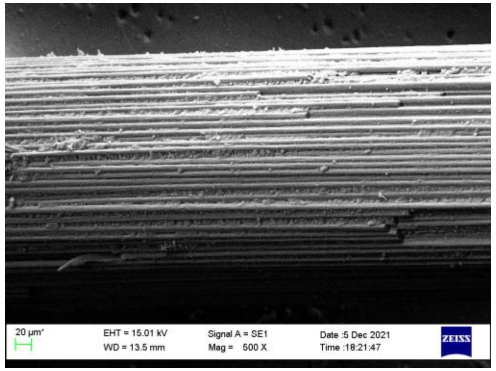
Loading rate effect

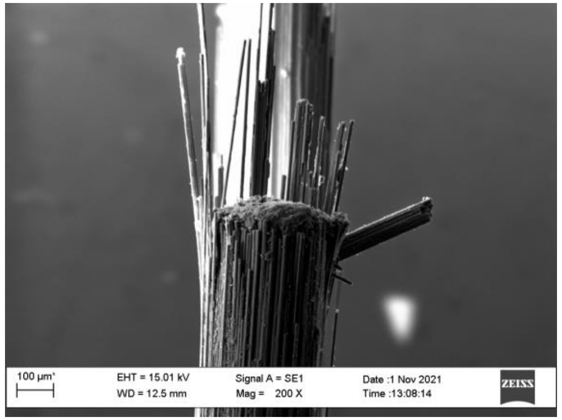
HR







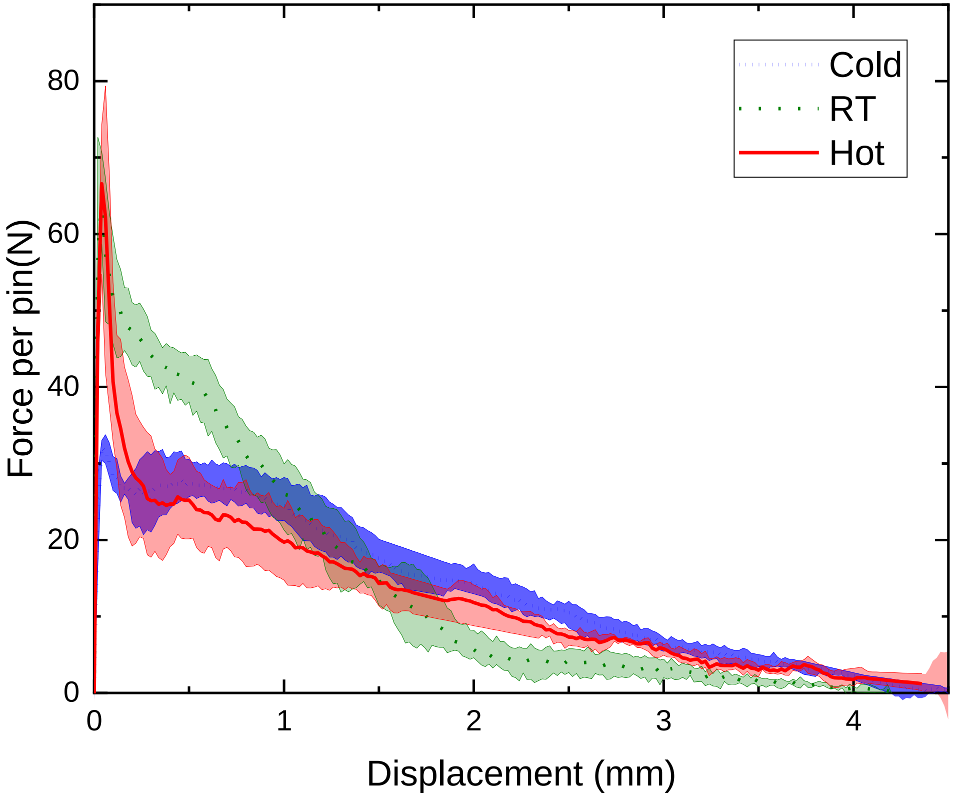




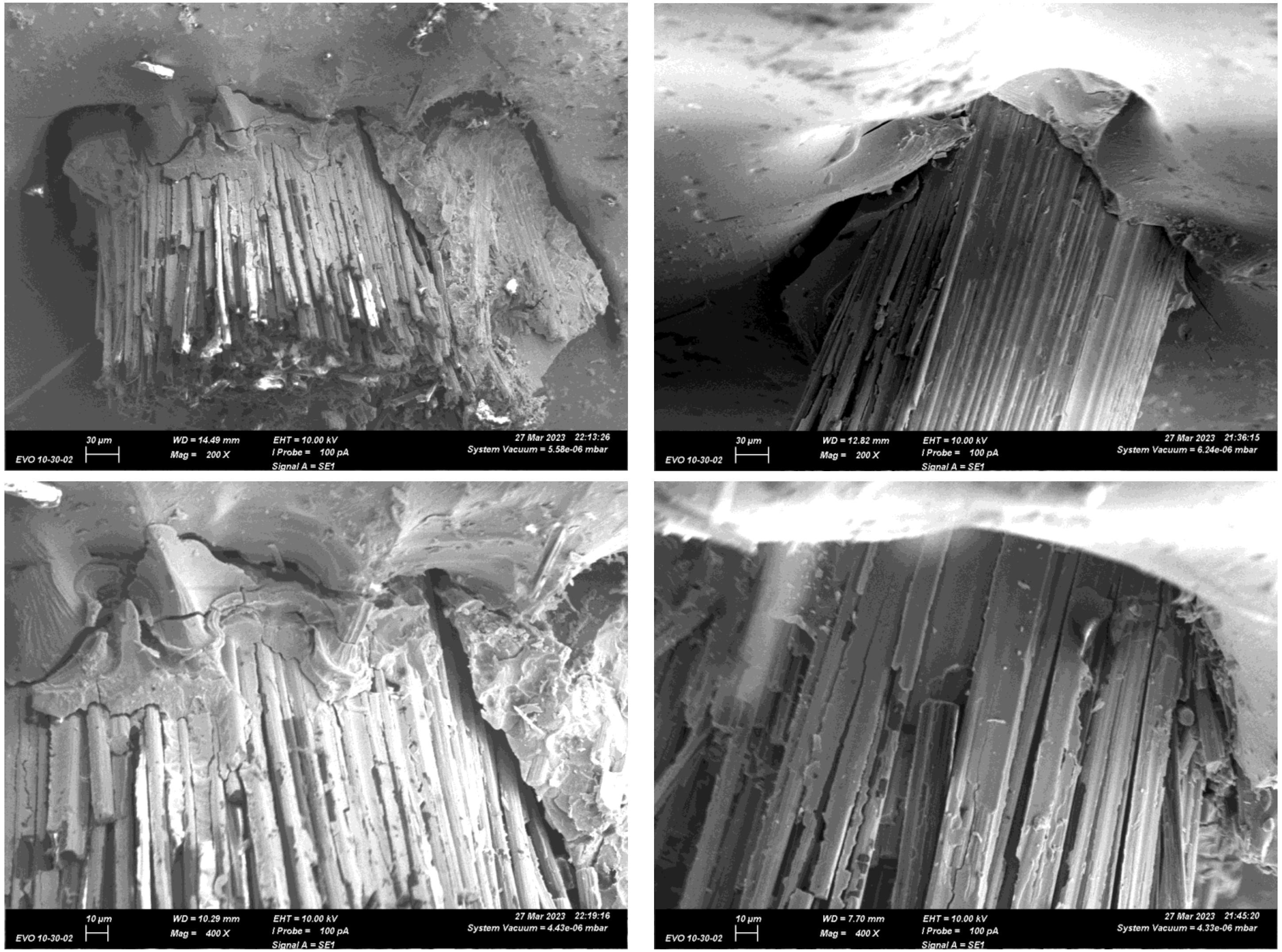
- Fibre splitting then break in Z-pin
- Debonding between BMI resin and T300 fibre in Z-pin

In situ temperature effect

- **Pure tension**

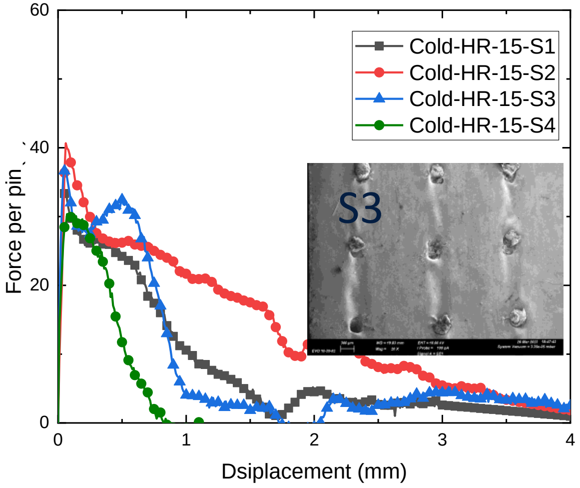


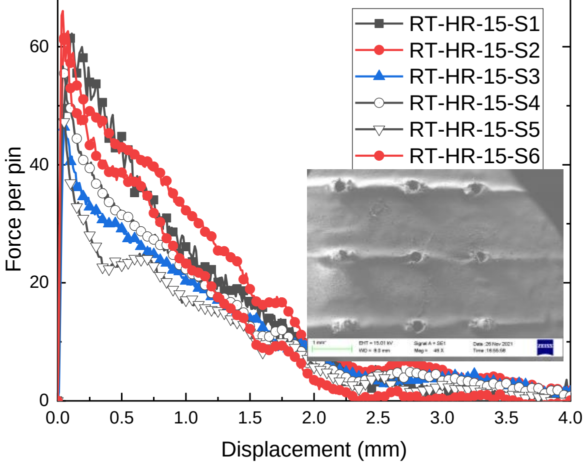
Cold **Hot**

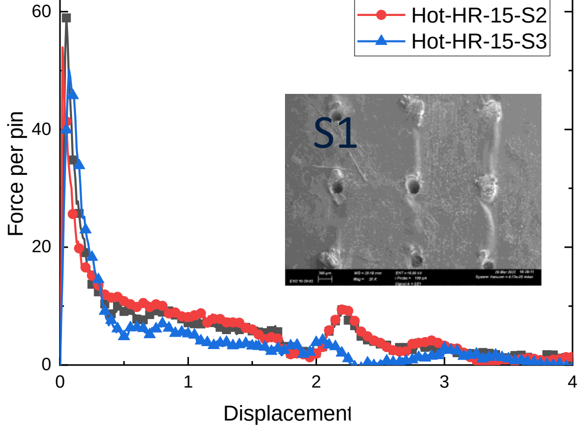


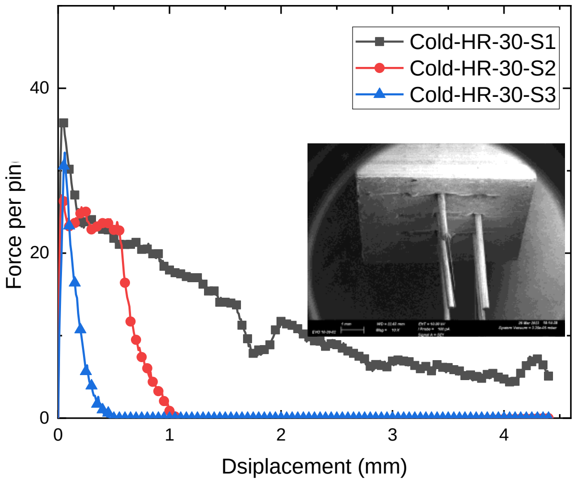
In situ temperature effect

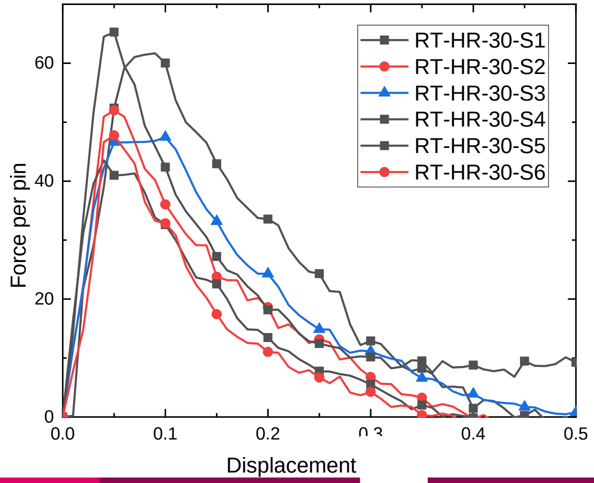
- **In situ temperature effect**

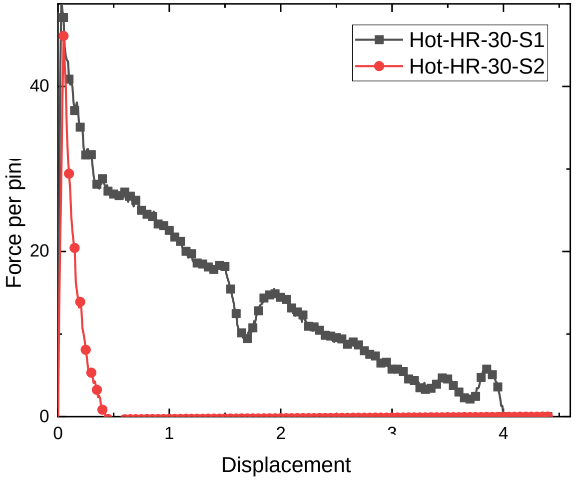












In situ temperature effect

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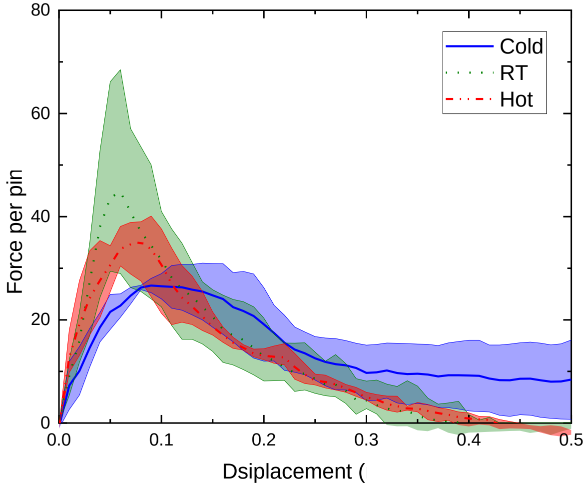

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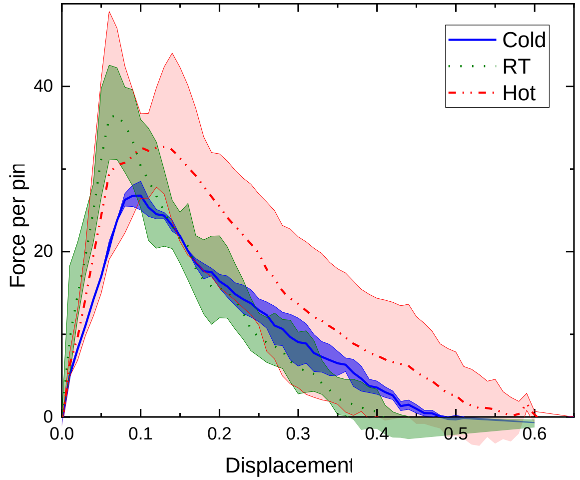

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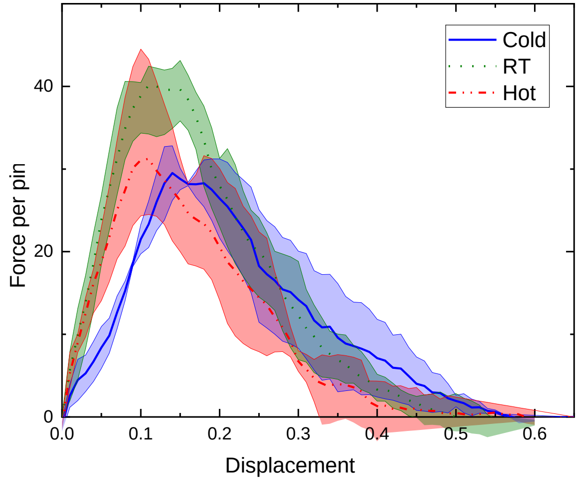
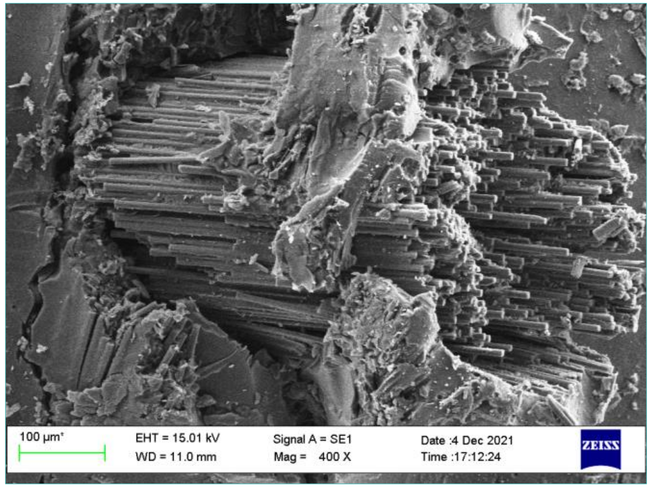
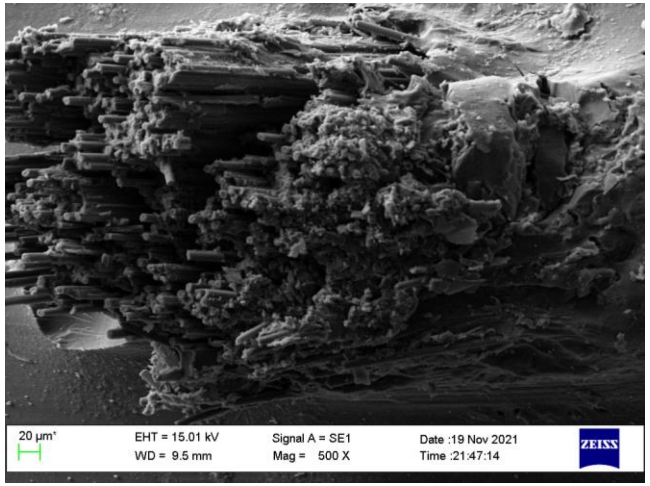
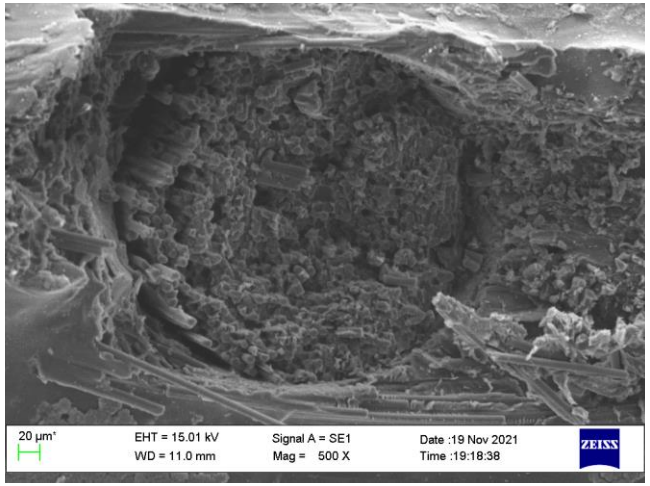


RT







In situ temperature effect

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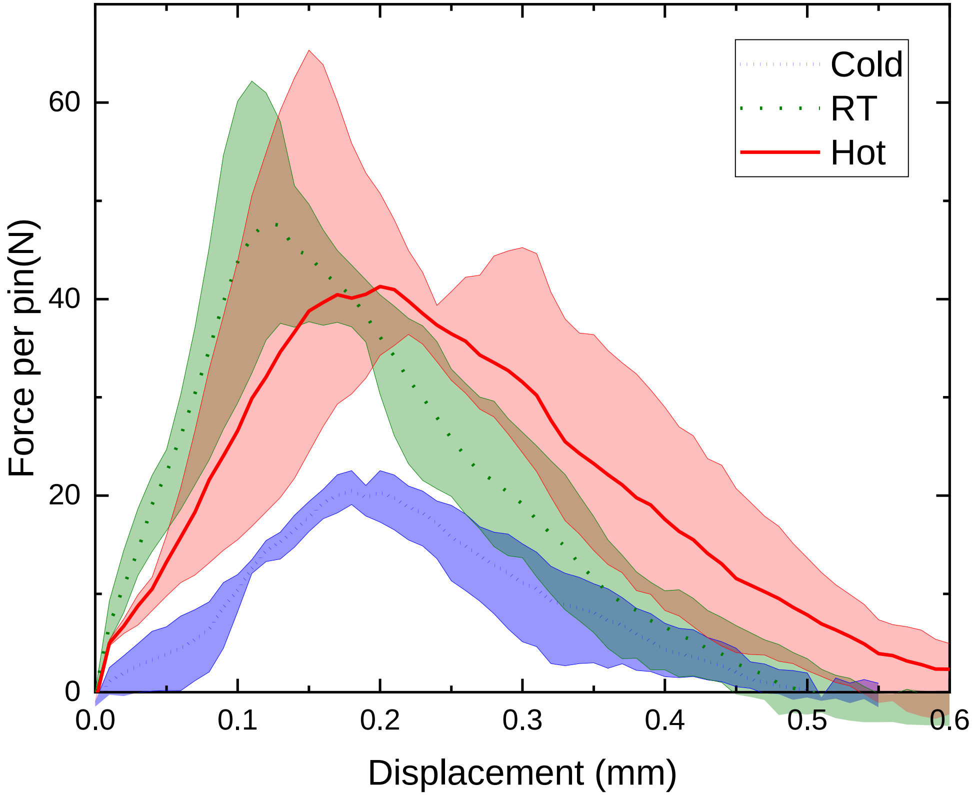
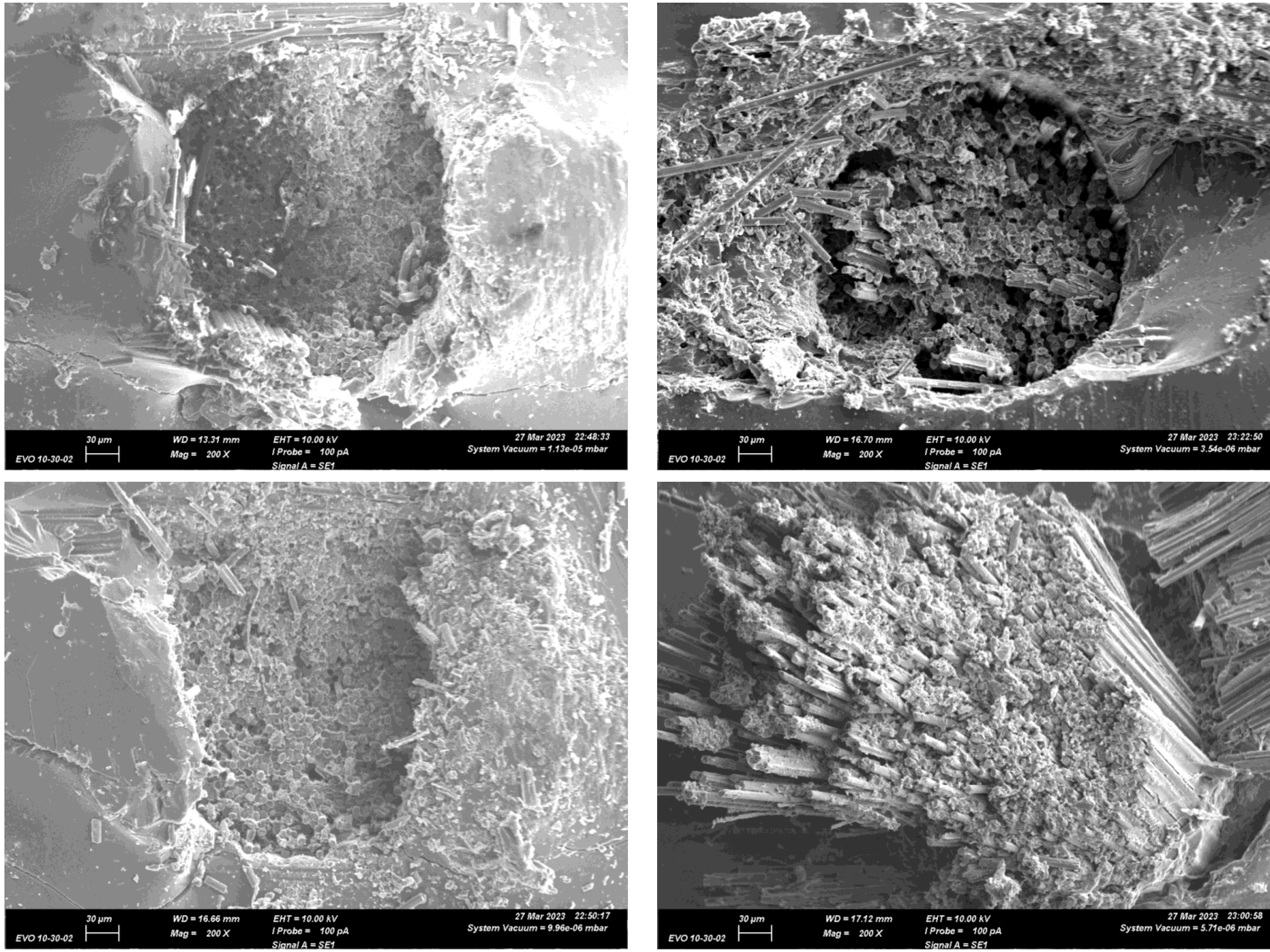
- **In situ temperature effect**



Cold

Hot



Conclusions

- The loading rate mainly affect the pull-out of behaviour of Z-pin;
- In-situ temperature condition has a significant influence on the mechanical behaviour of Z-pin:
  - Room temperature gives the best performance for all the loading conditions, while the cold condition gives the worst response;
  - Hot temperature stays in the middle, but the pull-out behaviour is quite unstable especially when β equals to15;
  - Under cold condition, the Z-pin tends to break even when the load is tension dominated.

Thanks