Fibre kinking fracture toughness of laminates under combined compression and shear

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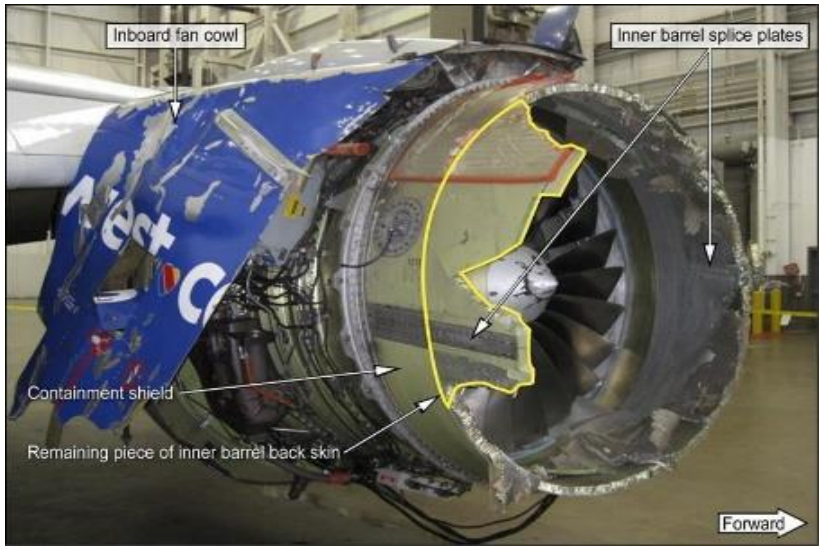
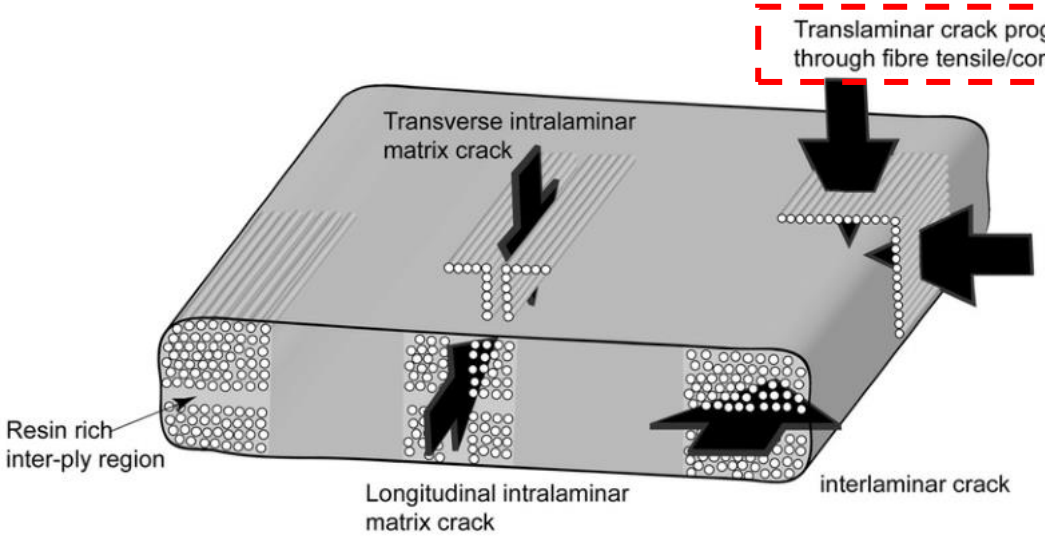
1 Background



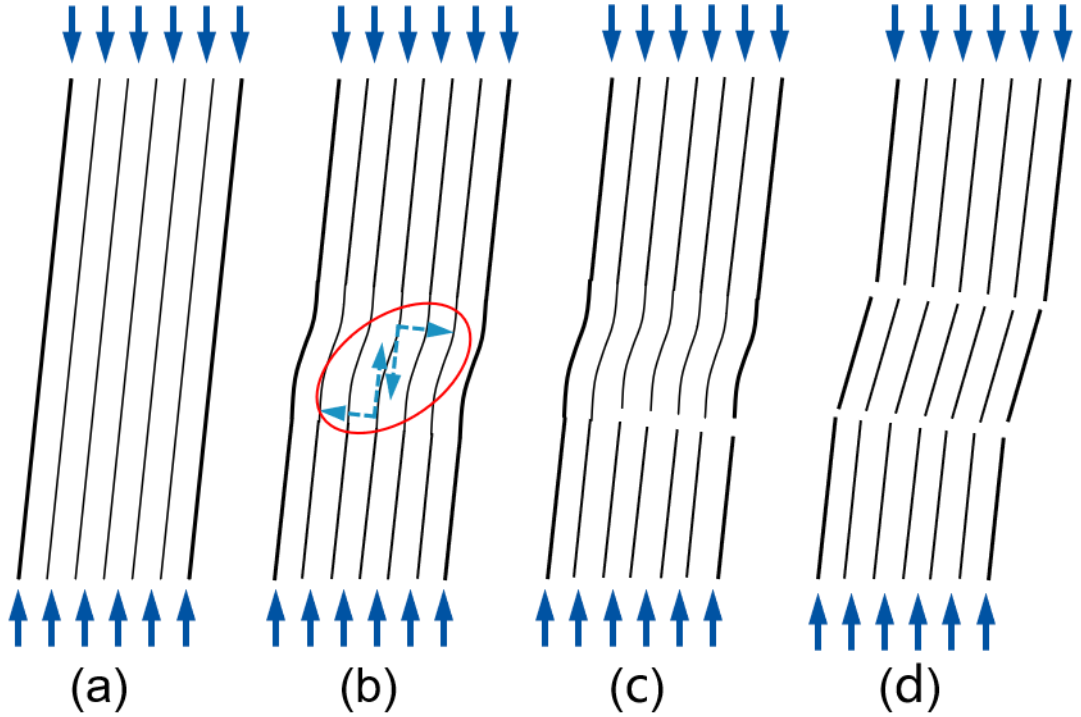
1 Background

Overview of ply-level failure modes



(Laffan et al, 2012)

Schematic diagram of kink band formation

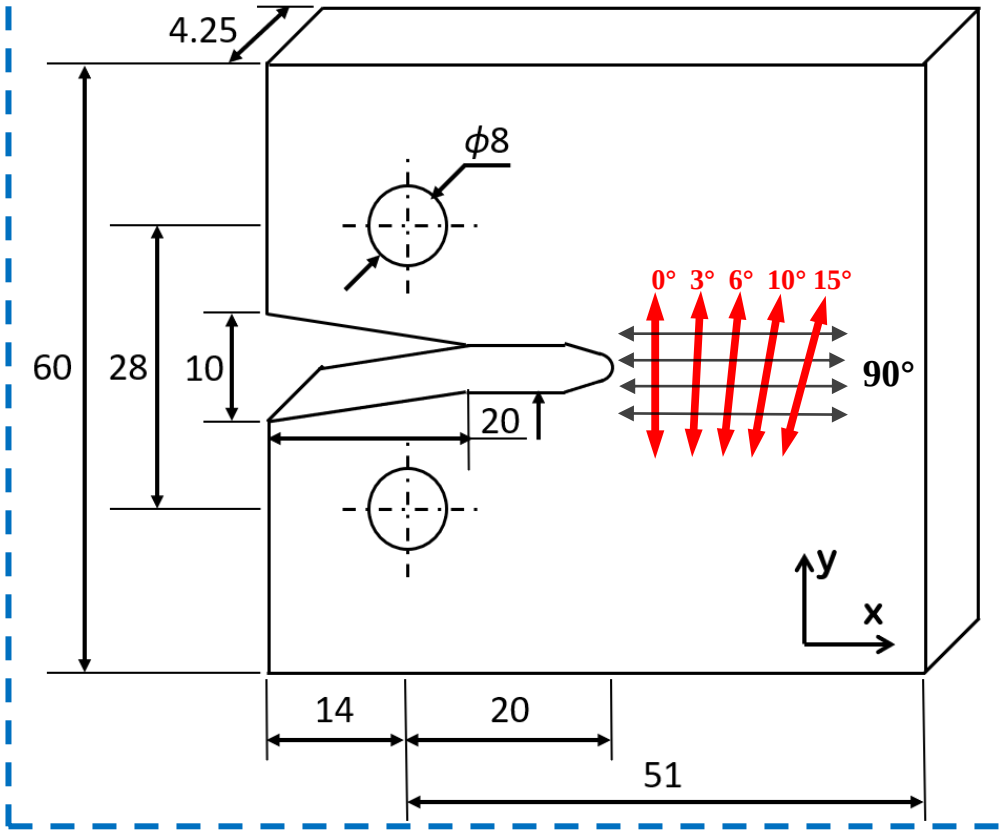


(Liu et al, 2023)

2 Specimen and experiment setup

Compact Compression specimen

$$Layup: [(90°/\theta)_8/90°]_s$$

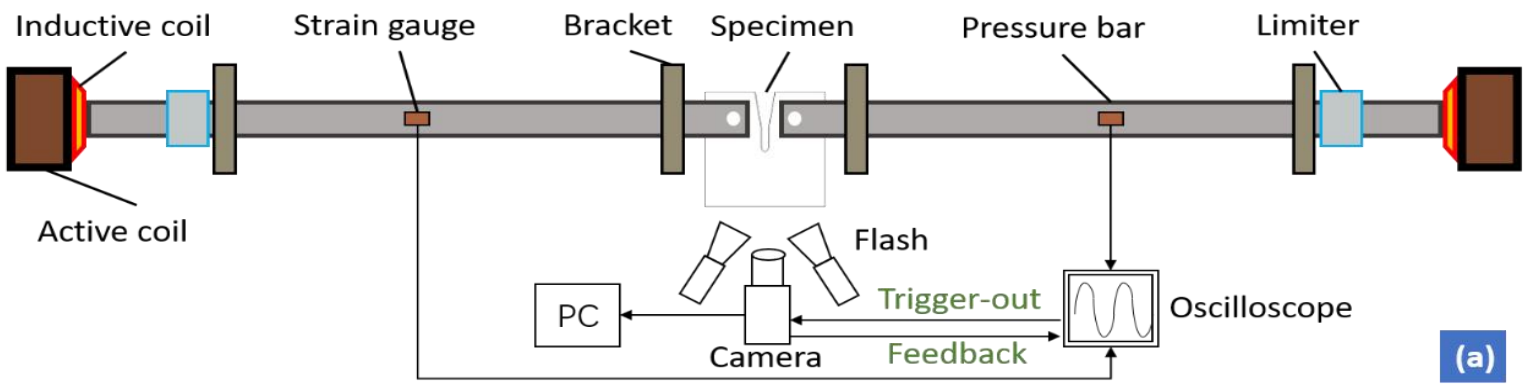


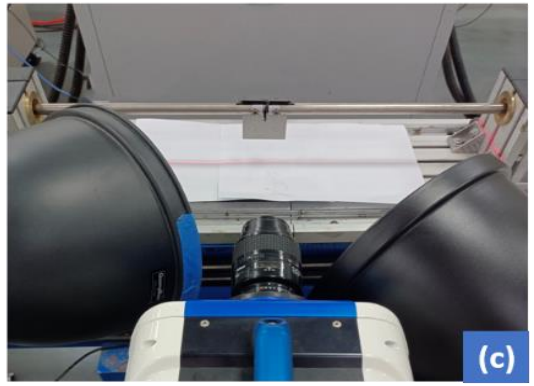
Mechanical properties of T700/LT-03A unidirectional laminae (GPa)			
Longitudinal	*Transverse*	*Shear*	*Major Poisson's ratio*
123	8.44	3.78	0.33

Calculated laminate stiffnesses (GPa)						
Off-axis angle	*Ex*	*Ey*	*Gxy*	*Nuxy*	*Nuyx*	*E'*
0°	69.484	**62.707**	3.780	0.045	0.04	30.77
3°	69.474	**60.428**	3.799	0.048	0.042	30.814
6°	69.445	**54.567**	3.858	0.058	0.046	30.948
10°	69.381	**44.666**	3.998	0.081	0.052	31.276
15°	68.283	**33.606**	4.278	0.123	0.059	31.939

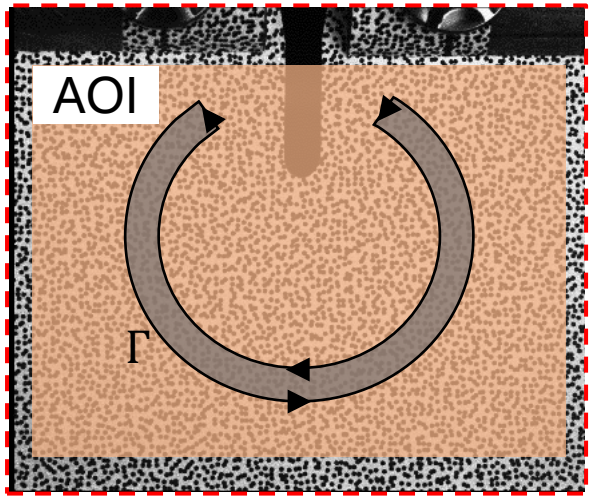
2 Specimen and experiment setup

Schematics of the electromagnetic Hopkinson bar system



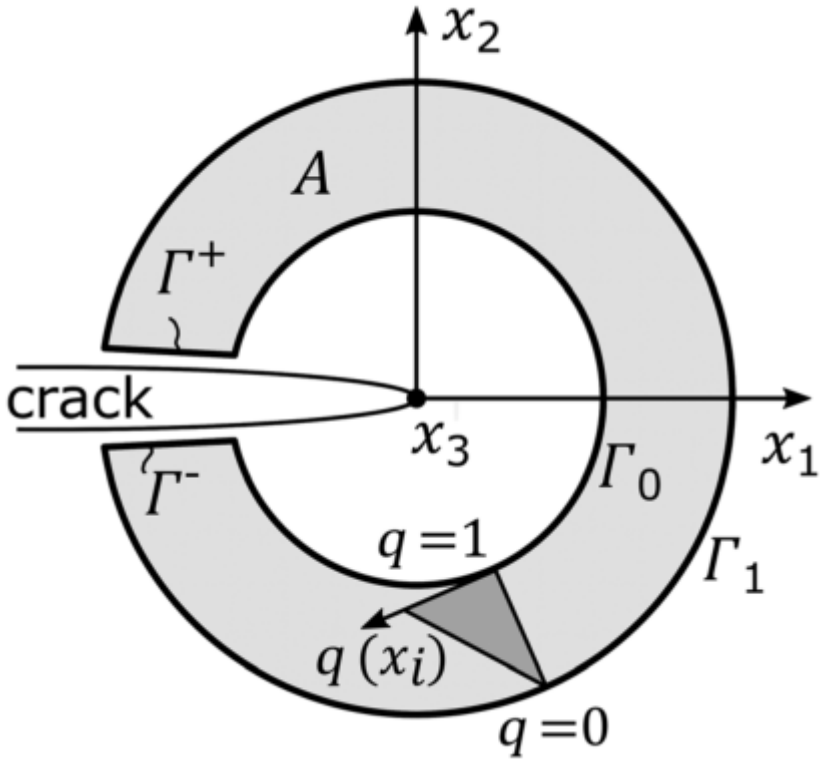


(b) the inductive and active coils, (c) high-speed camera, (d) limiter.



Field of view

Data reduction



- Decompose the displacement field

$$u_{crack} = u_{\mathrm{I}} + u_{\mathrm{II}} = \frac{1}{2}\begin{Bmatrix} u_1 + u_1' \\ u_2 - u_2' \end{Bmatrix} + \frac{1}{2}\begin{Bmatrix} u_1 - u_1' \\ u_2 + u_2' \end{Bmatrix}$$

where $u_i' = u(x_1, -x_2)_i$

- Dynamic J-integral method

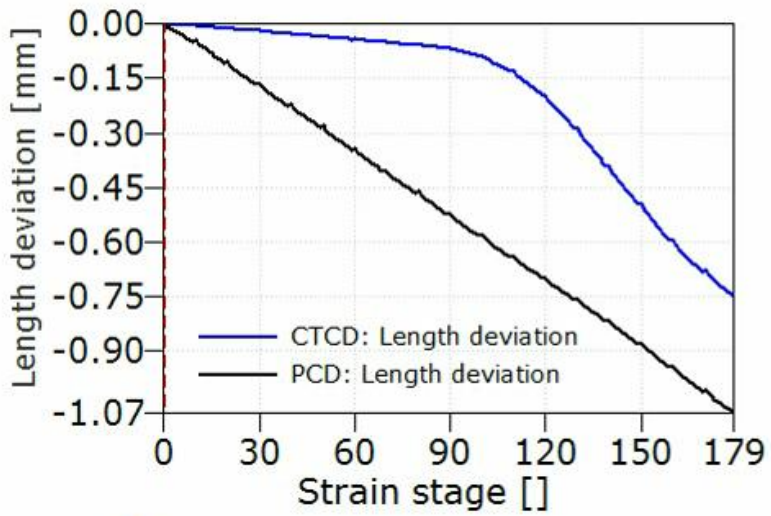
$$J_M^{lam} = \sum_A \left\{ \left[(W_M + K_M)\delta_{1j} - \sigma_{M\,ij}\Delta u_{M\,i} \right] \frac{\Delta q}{\Delta x_j} \Delta A \right\}$$

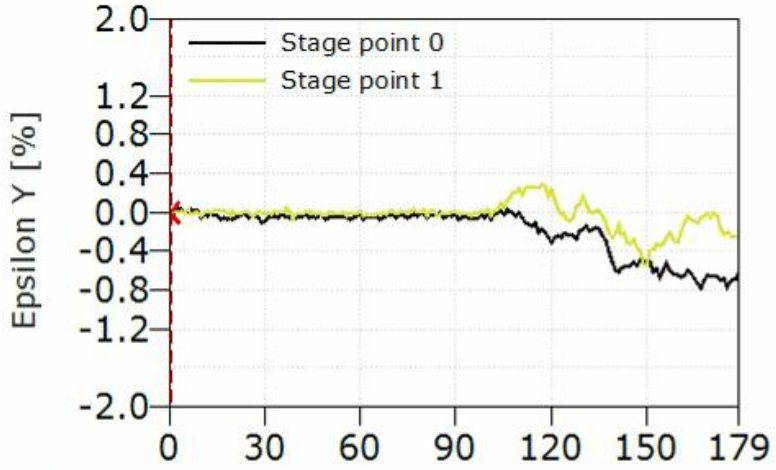
$$+ \sum_A \left[\rho \left(\ddot{u}_{M\,i}\Delta u_{M\,i} - \dot{u}_{M\,i}\frac{\Delta u_{M\,i}}{\Delta x_1} \right) \Delta A \right] \qquad (M = \mathrm{I}, \mathrm{II})$$

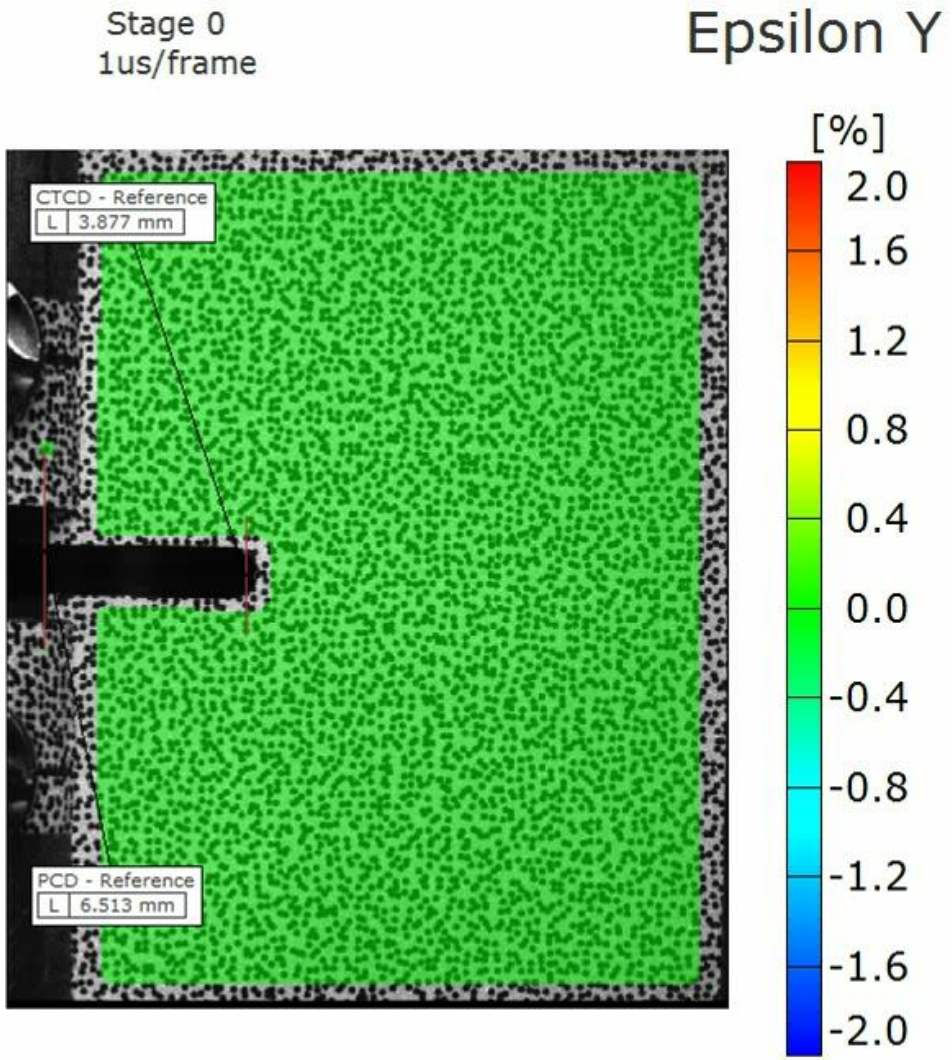
- Fibre fracture toughness along the loading direction

$$J_{\mathrm{I}}^{fibre} = 2.125 \cdot J_{\mathrm{I}}^{lam}$$

4 Results and discussion

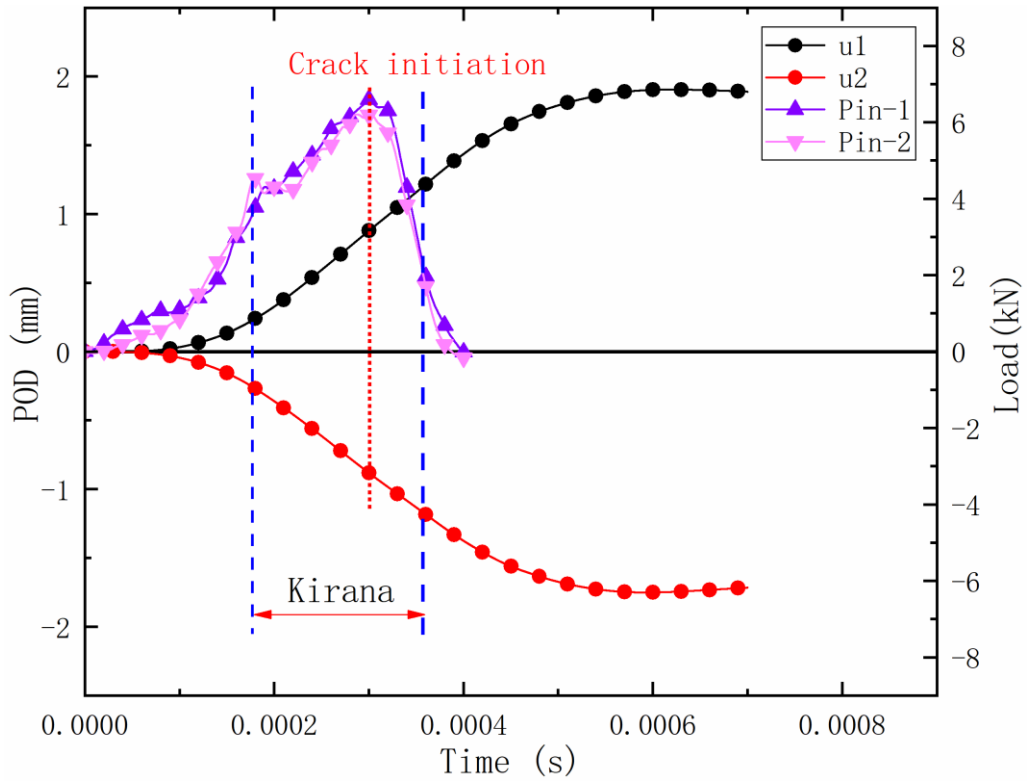






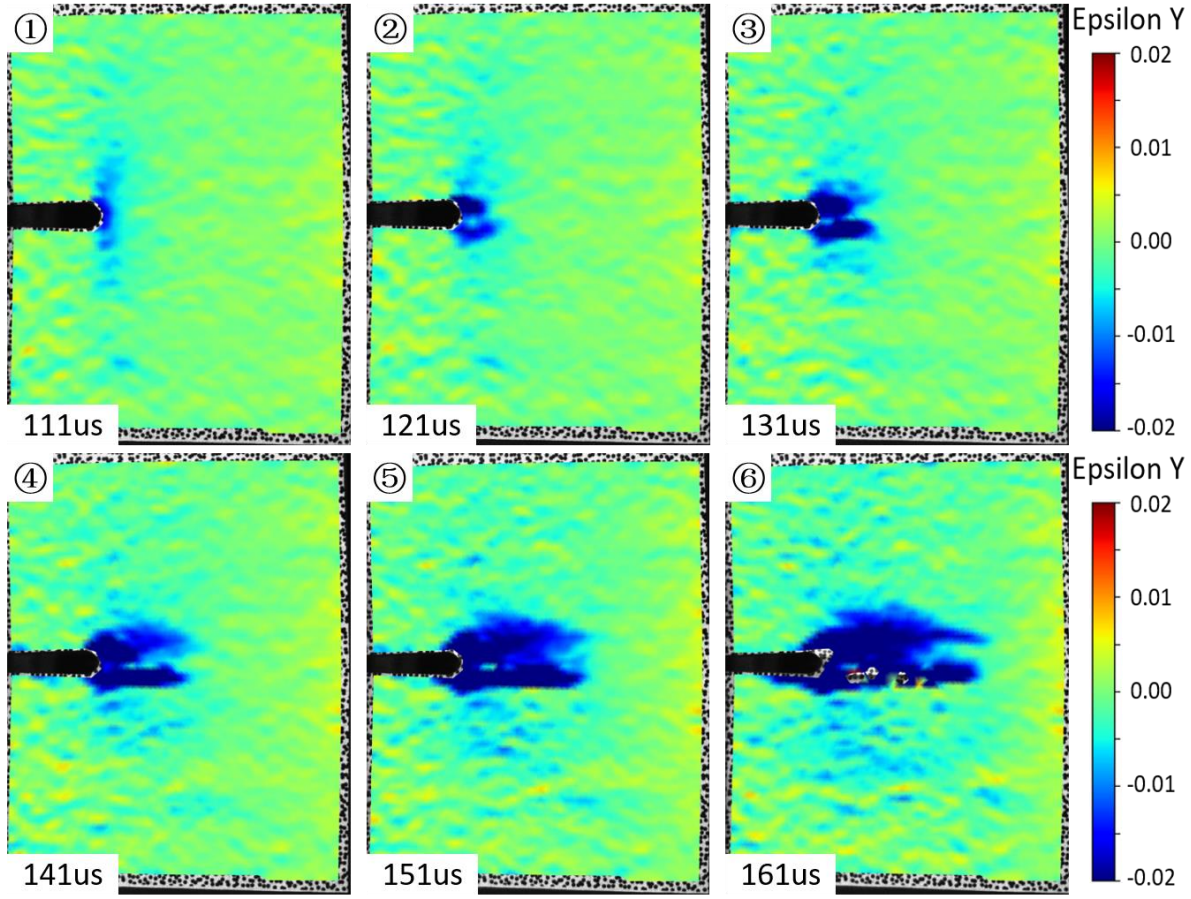
4 Results and discussion

The closing displacement and load of pins



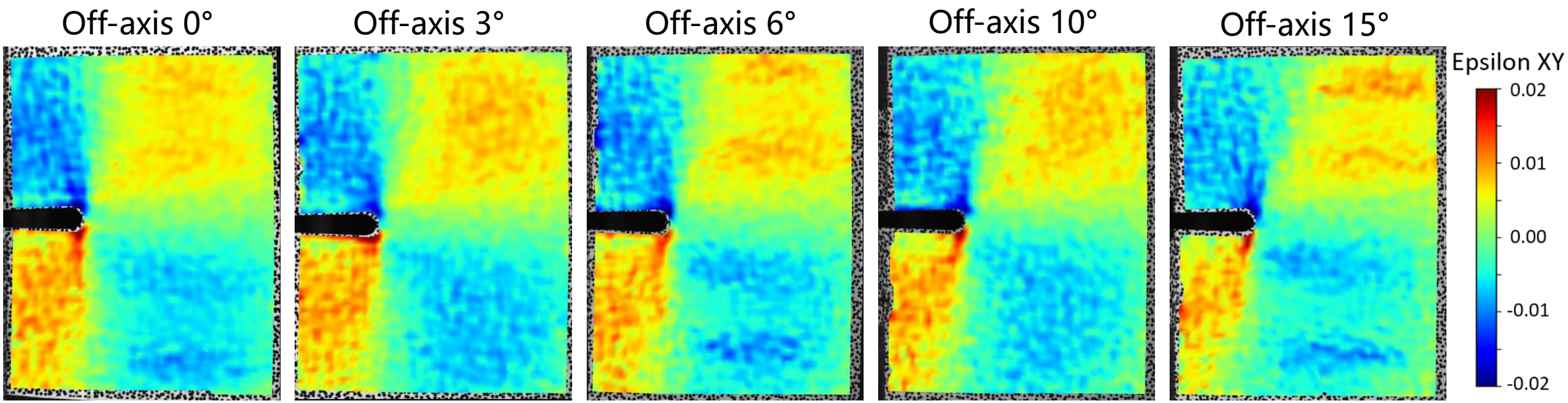
good symmetry

compression fracture process

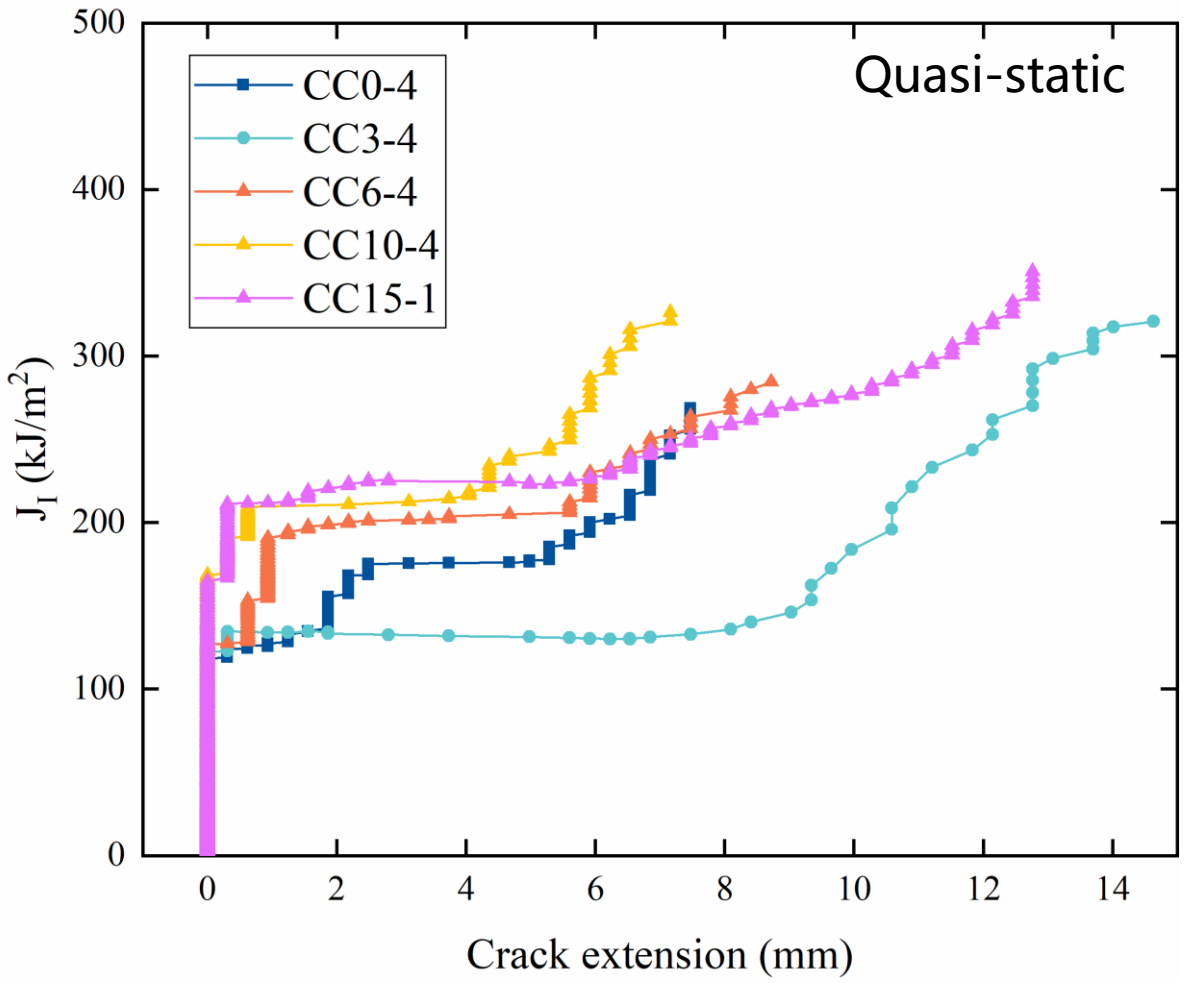


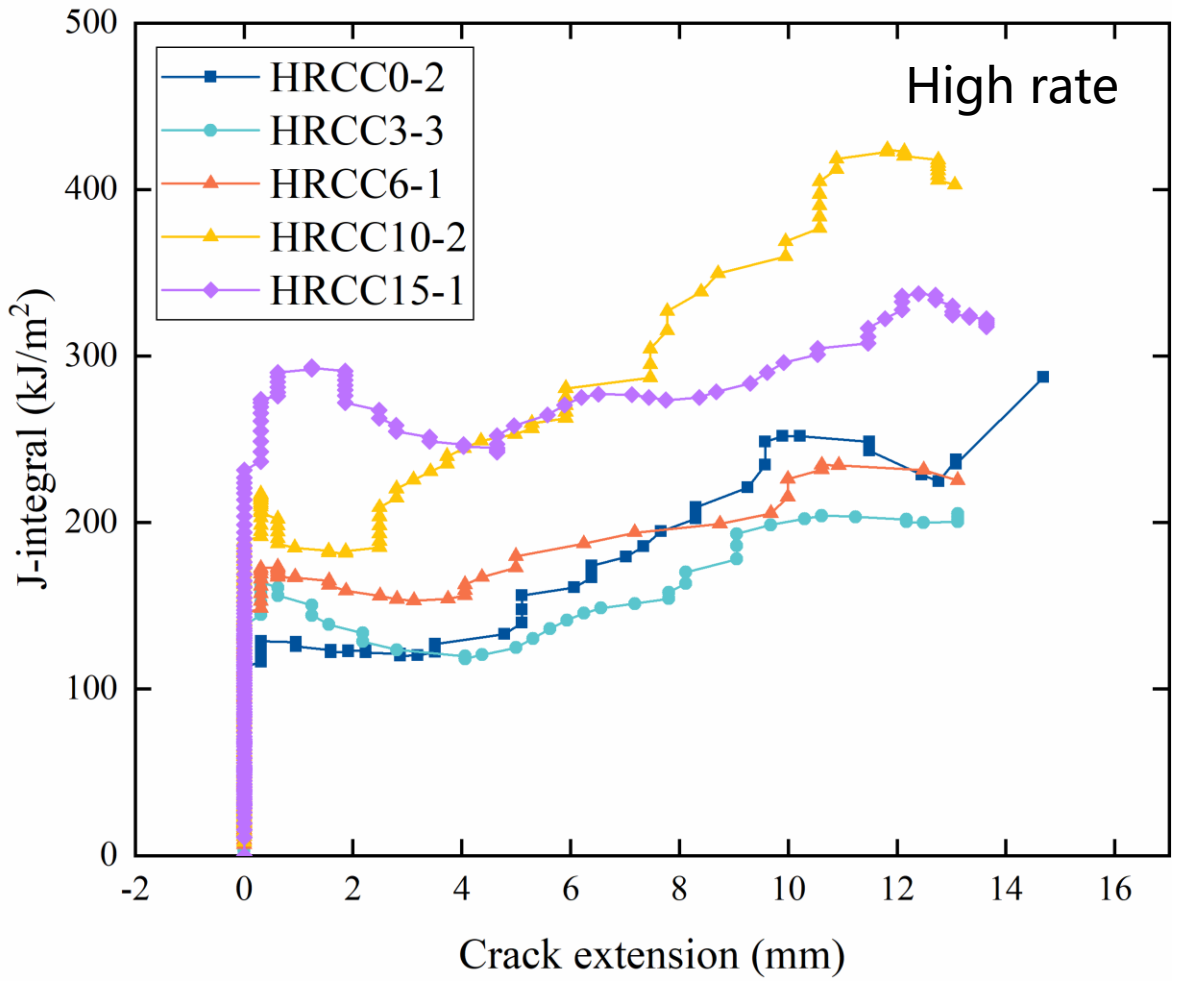
Results and discussion

Shear strain at crack initiation



4 Results and discussion





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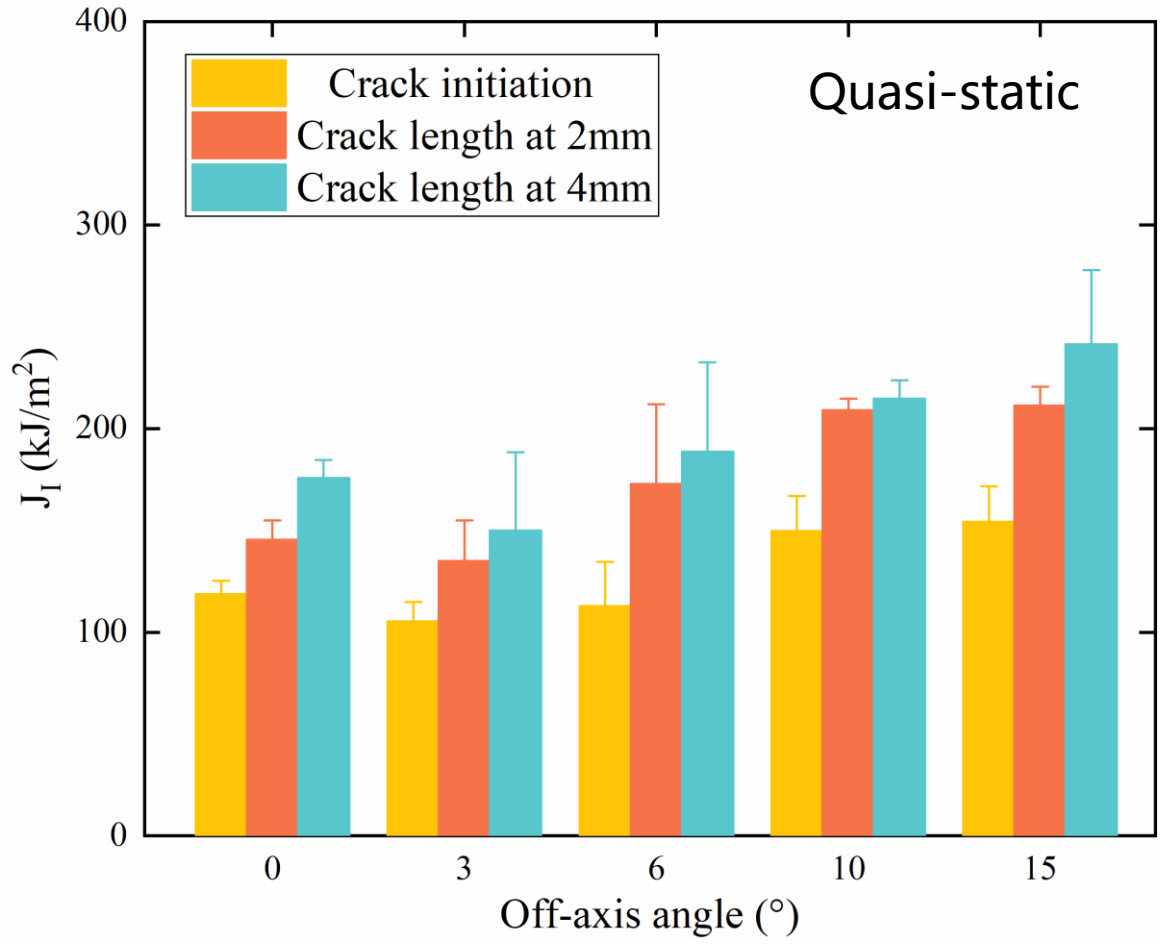
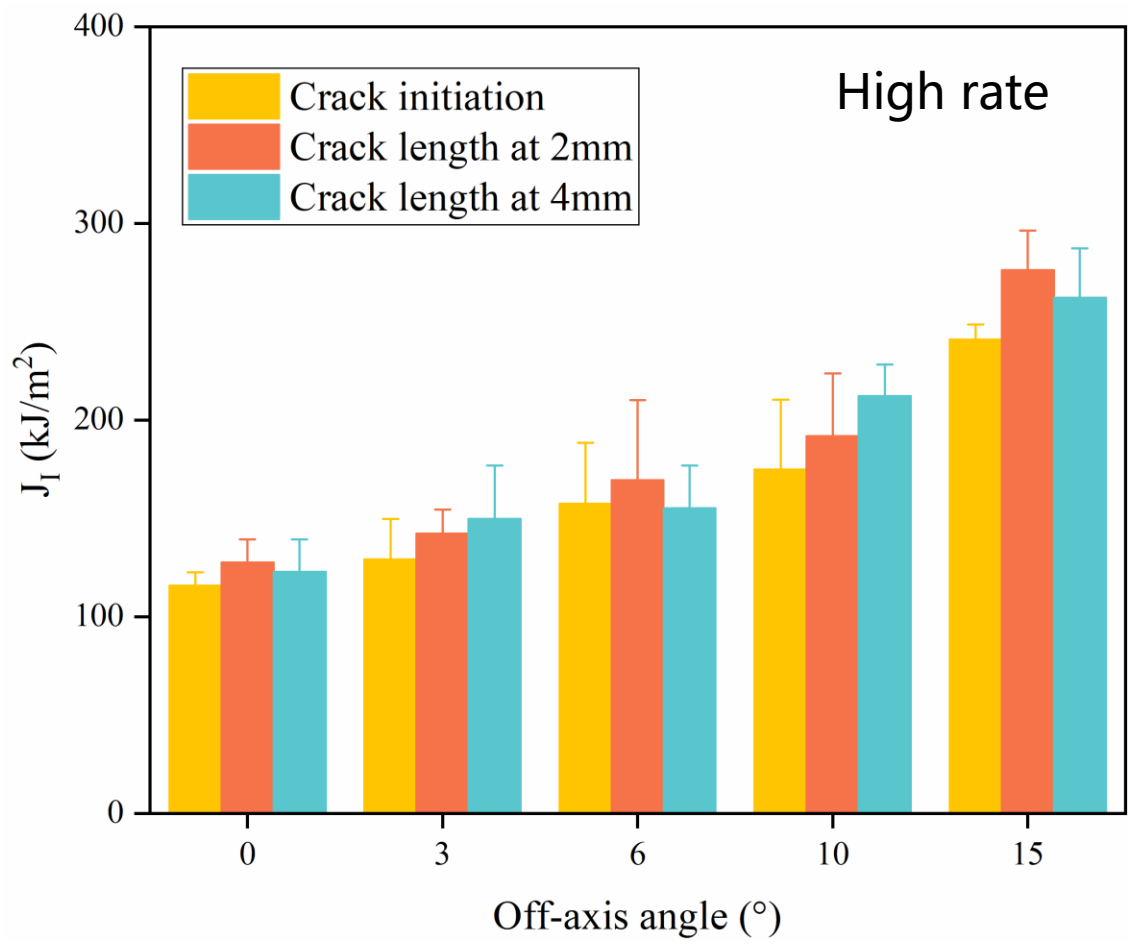
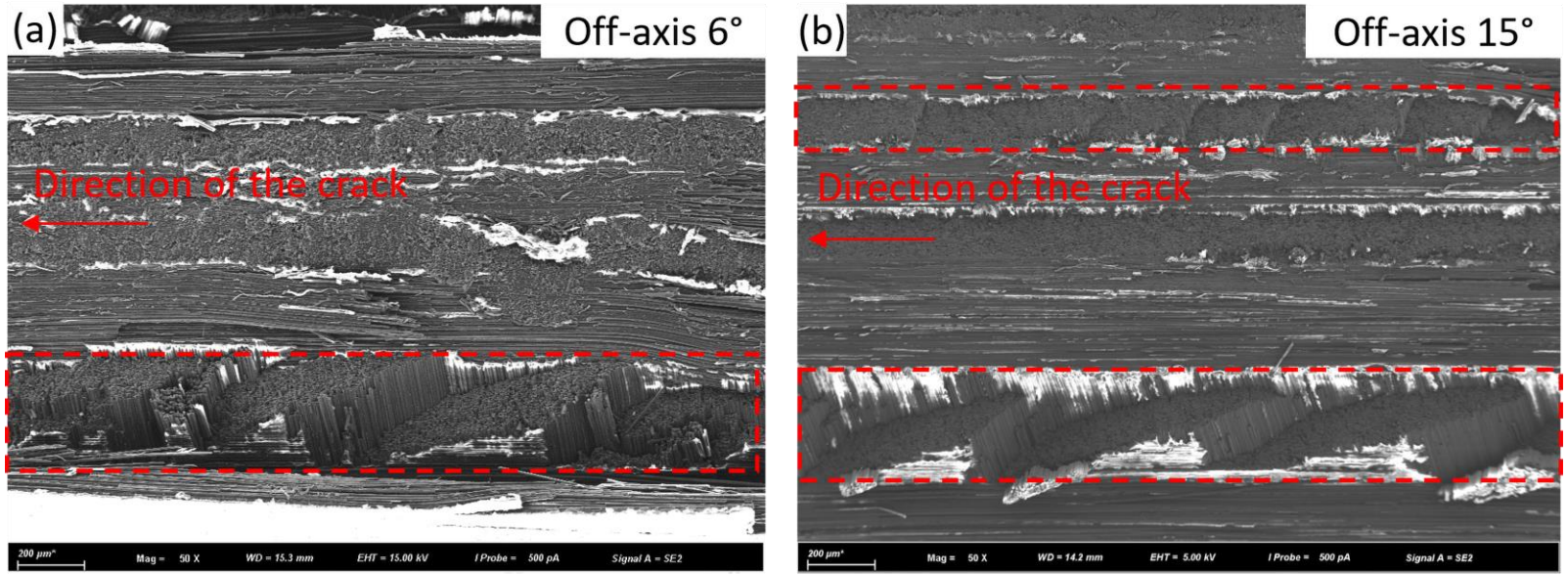


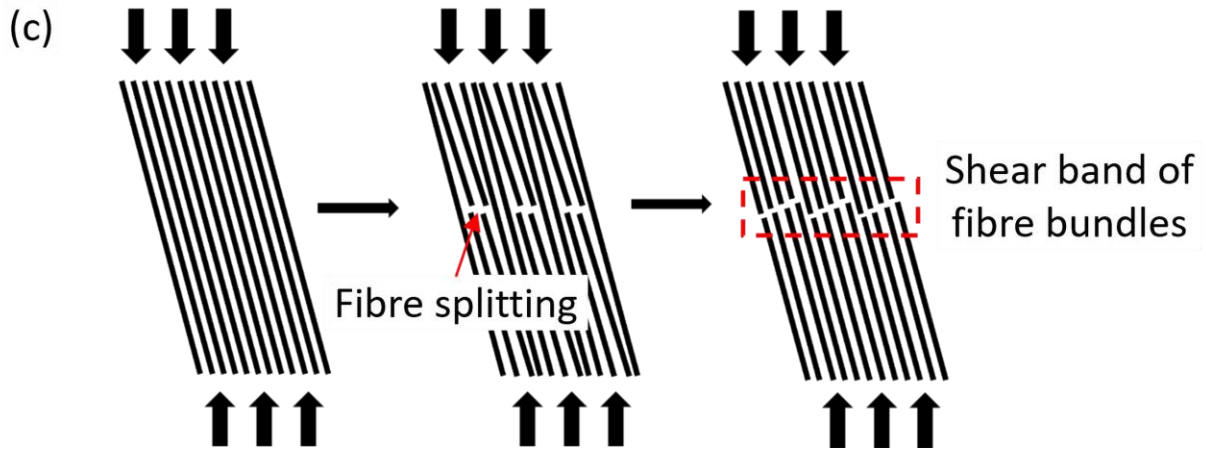


Fracture toughness increases with increasing off-axis angle.

4 Results and discussion

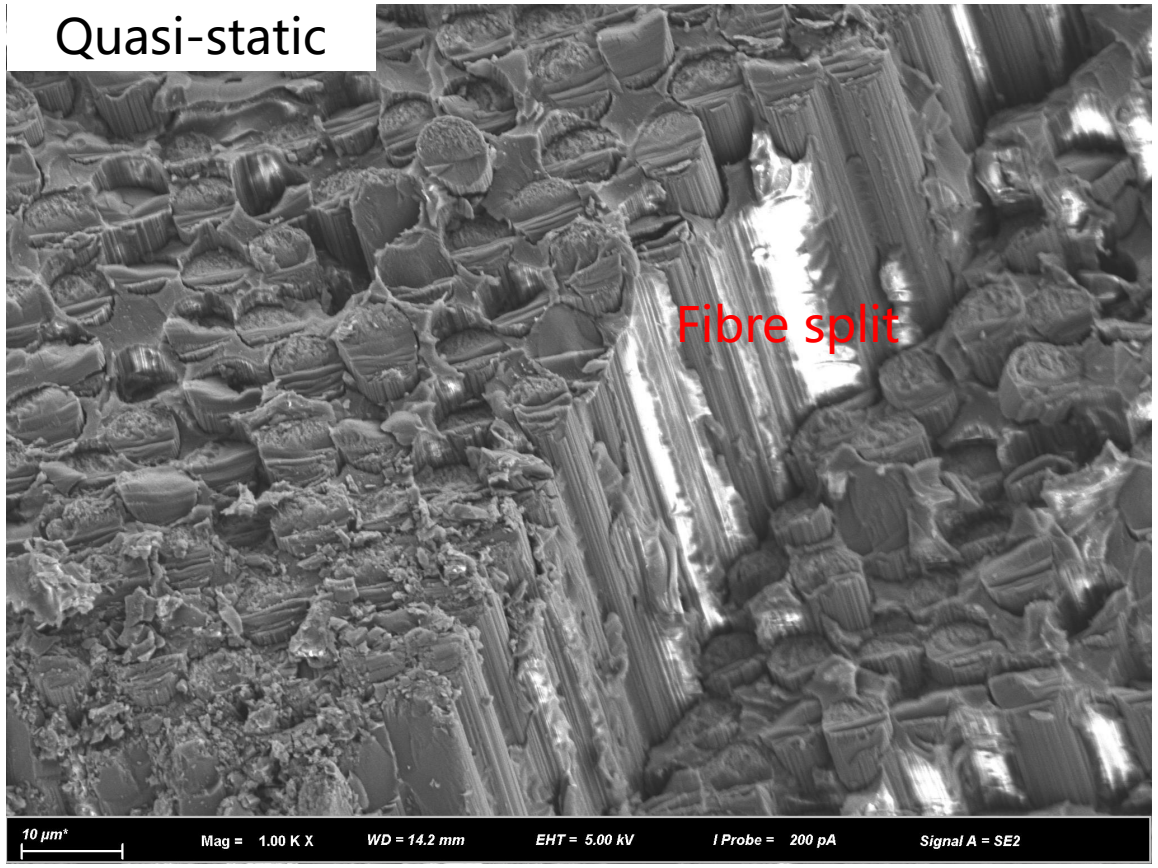
Quasi-static



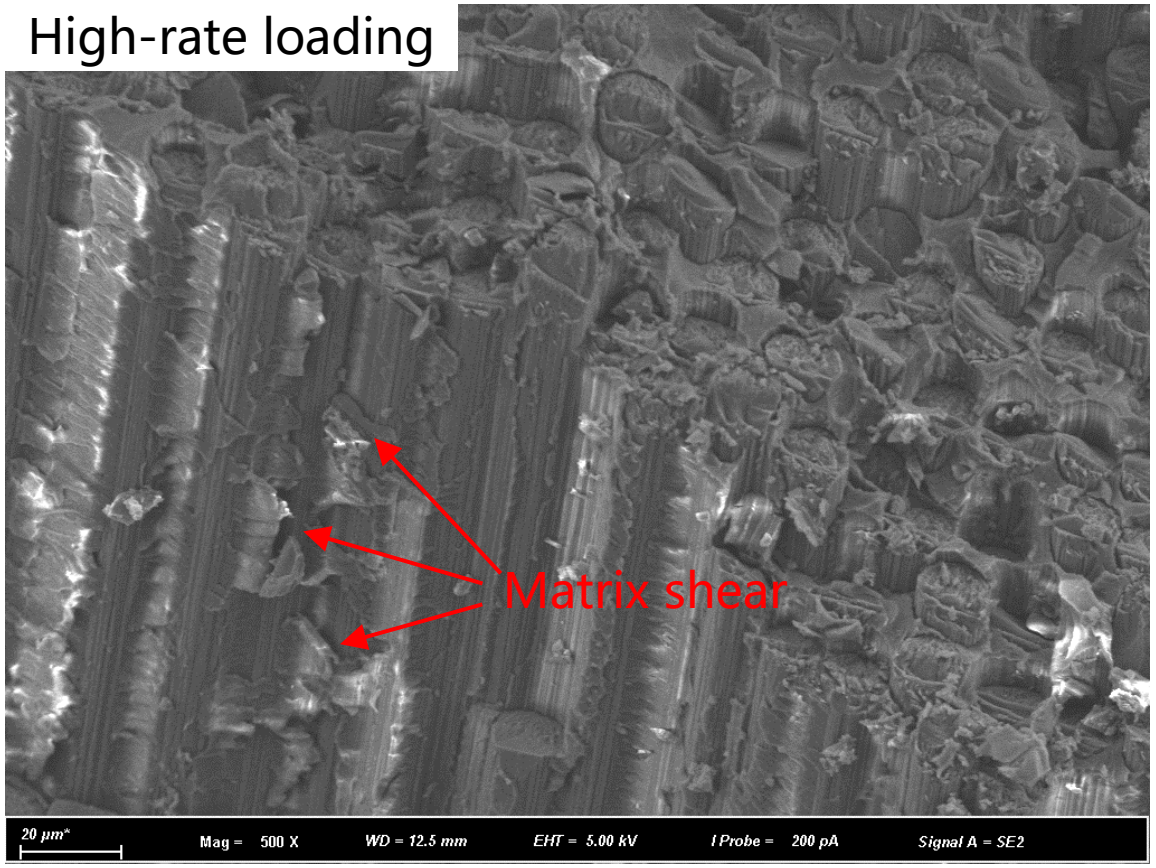


4 Results and discussion

Quasi-static



High-rate loading



Thanks!

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