Mechanical Property and Microstructure Analysis of Sand Cast A356 Modified with Cerium

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Background & rationale

- Wide application in automotive industries;
- Rare earth elements potentially refine the microstructure and improve the mechanical properties of aluminum alloys;
- Sand-cast A356 alloyed with 1wt.% of Cerium (Ce) addition was studied.

Objective

- Experimentally identify the optimal heat treatment process to refine the microstructure and mechanical properties of A356-1wt.% Ce;
- Compare the alloy's hardness, tensile strength, and fatigue life properties with unmodified A356;
- Microstructure characterization of modified A356-1wt.% Ce and fractography observation.

Methodology and experimental setup

- Perform T6 heat treatment (solid solution 540ºC for 2 hours, aging 175 ºC 0.5-96 hours) procedure on tensile and fatigue samples;
- Conducting Vicker’s hardness test, tensile test, and fatigue test on heat-treated samples of cast and heat-treated alloys;
- Characterizing grain structure and fractography with optical and SEM methods;
- Discussion of mechanical properties on as-cast and heat-treated modifies alloys and A356 alloys.

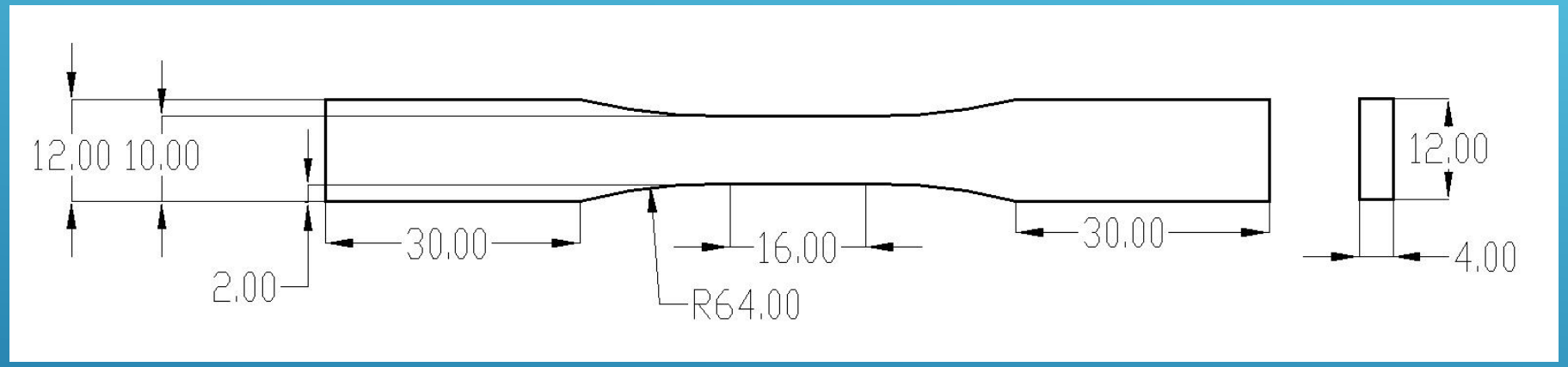

Fig. 1 Fatigue test coupon geometry and dimension (unit: mm)

Results

1. Hardness property

- Solid solution: 540℃ for 2 hours
- Artificial aging: 175 ℃ 0.5-96 hours
- Peak 113 (HV) at 28 hours

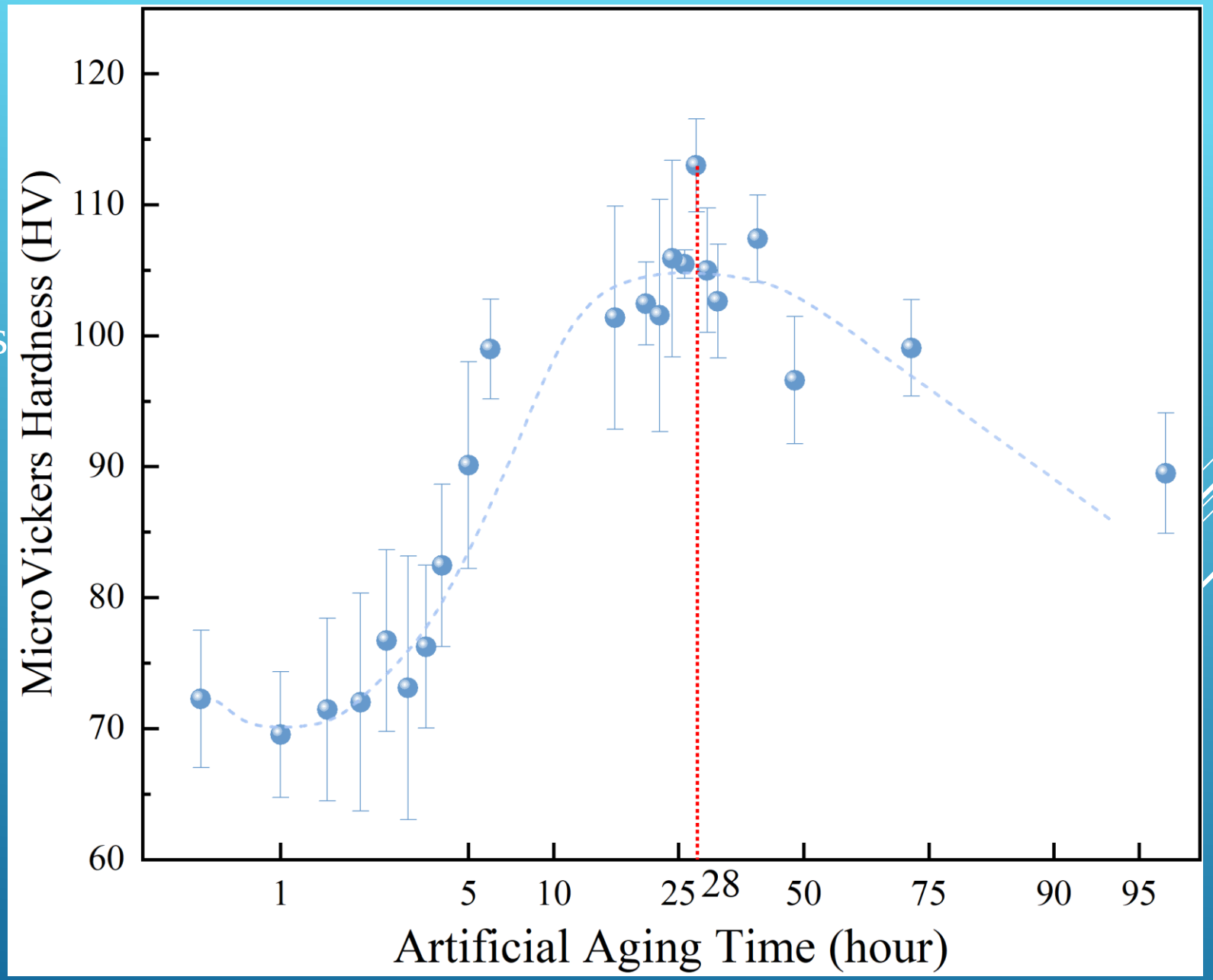

Fig. 2 Micro Vickers hardness as a function of various artificial 0-96 aging hours.

6. XRD analysis

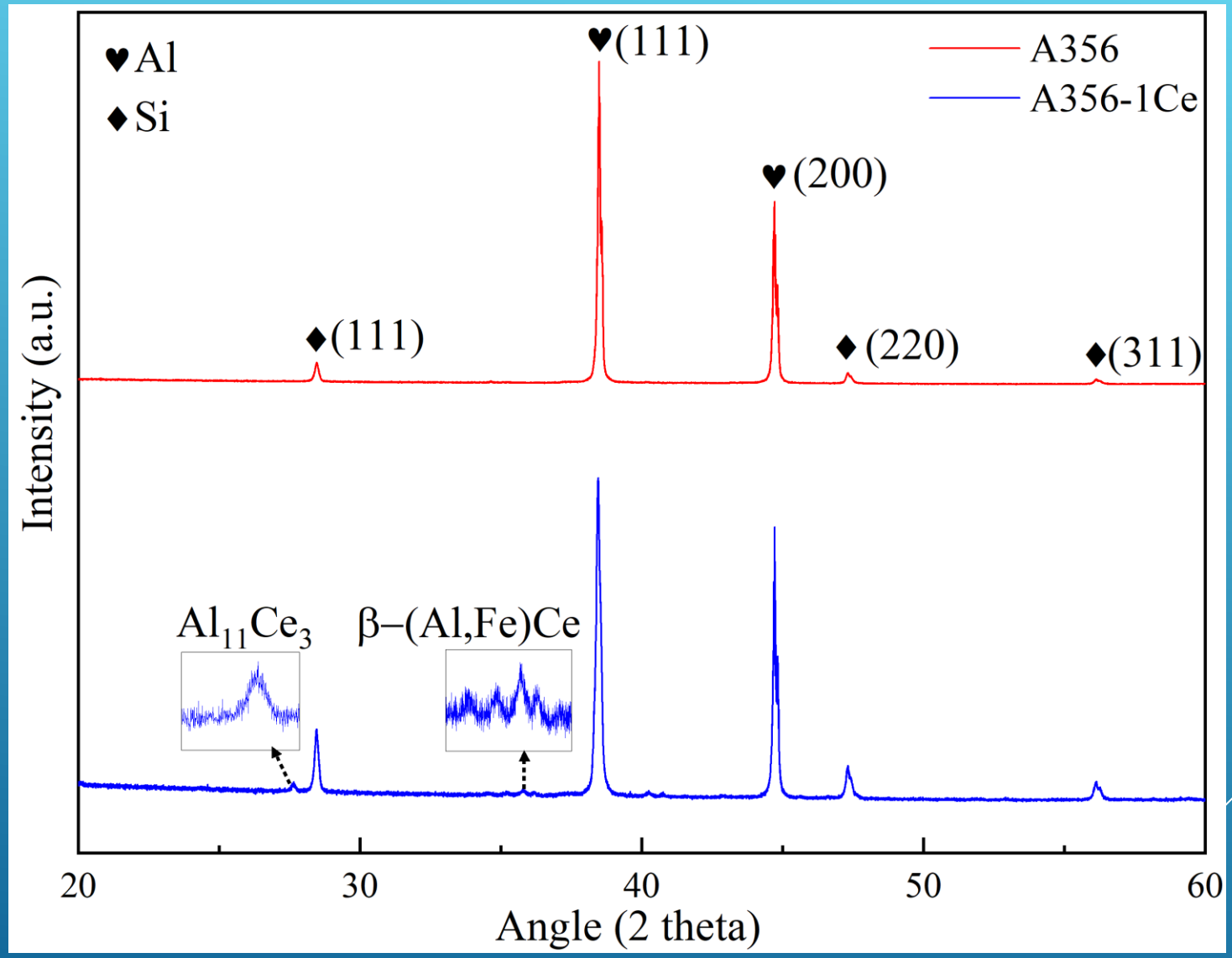

Fig. 3 X-Ray phase identification for A356, as-cast A356-1Ce coupons.

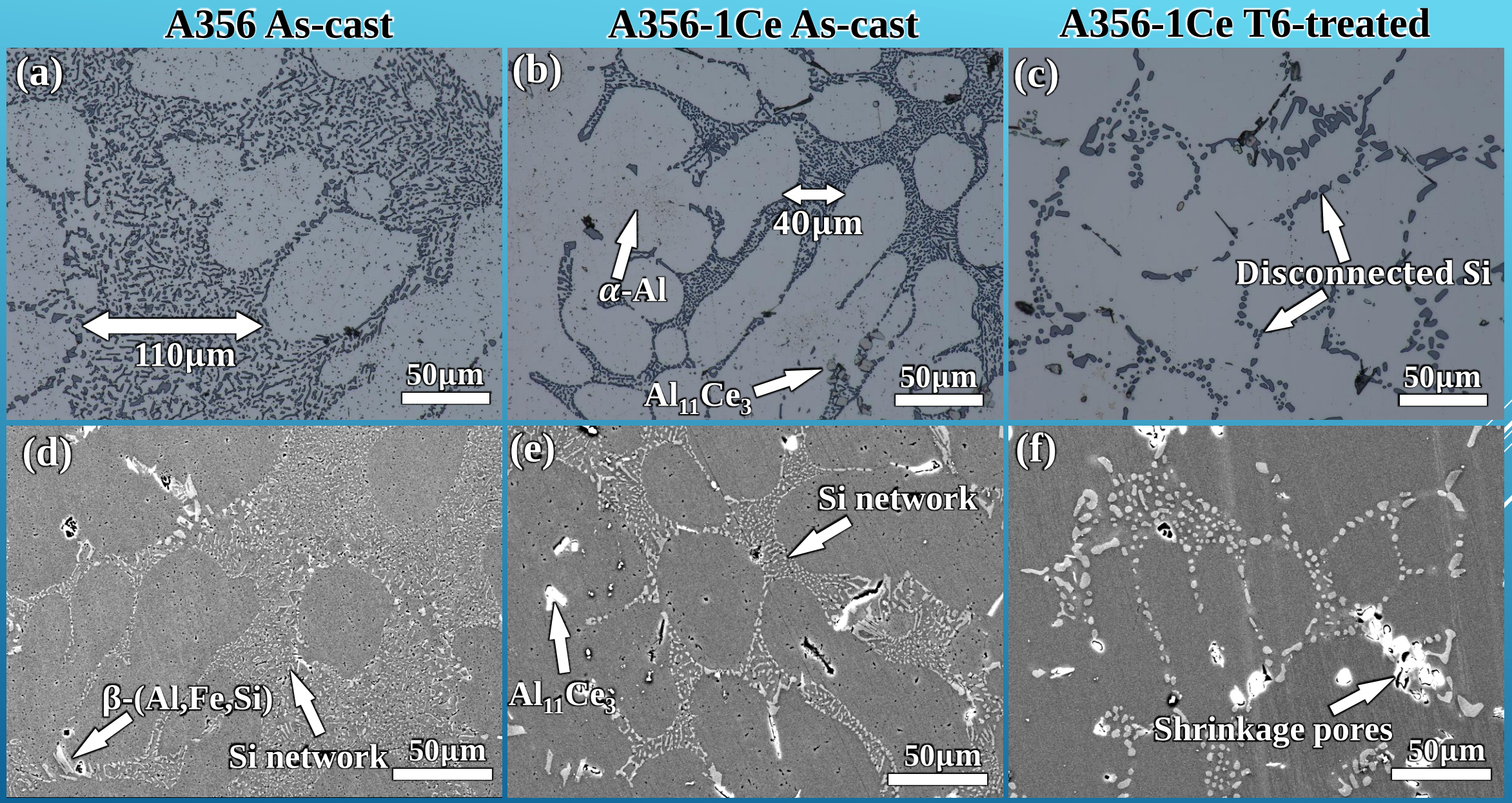

Fig. 4 T6 heat treatment effect on microstructure for A356, as-cast A356-1Ce, and T6-treated A356-1Ce coupons.

2. Tensile properties and characterization

- Uniaxial room temperature tensile test;
- Strain rate: 0.005 mm/s
- YS and UTS improved after heat treatment;
- Repeat as-cast+ heat-treated

	YS(MPa)	UTS(MPa)	EL(%)
A356-Cast	92	150	3.14
A356-1Ce-Cast	110	152.4	1.5
A356-1Ce-HT	217.7	238.9	0.7

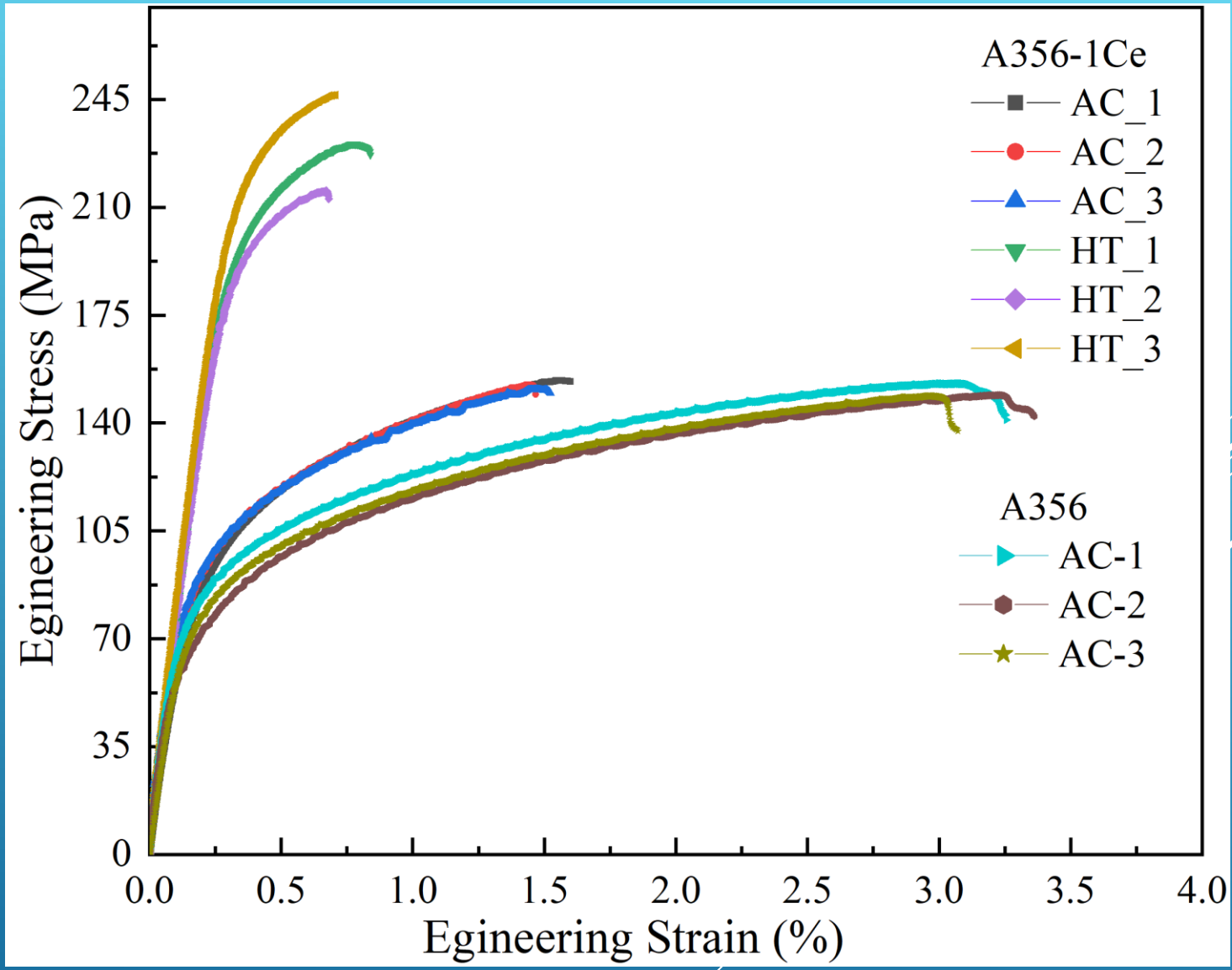

Fig. 5 Stress-strain curves for A356, as-cast and T6-treated A356-1Ce. AC: as-cast; T6: T6 heat treatment.

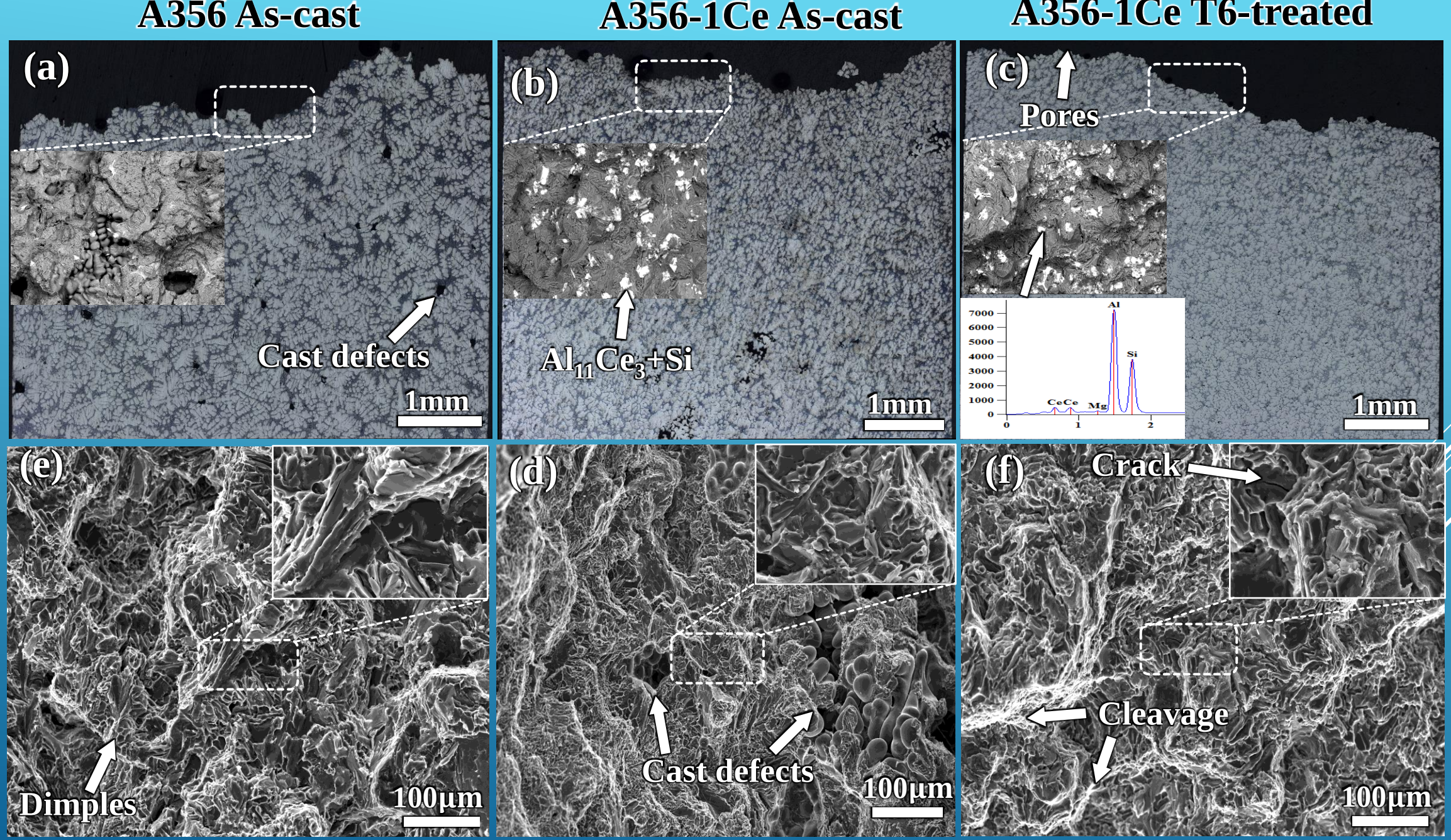

Fig. 6 Tensile fractography optical, second back-scanned, and EDS observation for A356, A356-1Ce, and T6-treated A356-1Ce coupons.

3. Fatigue properties and characterization

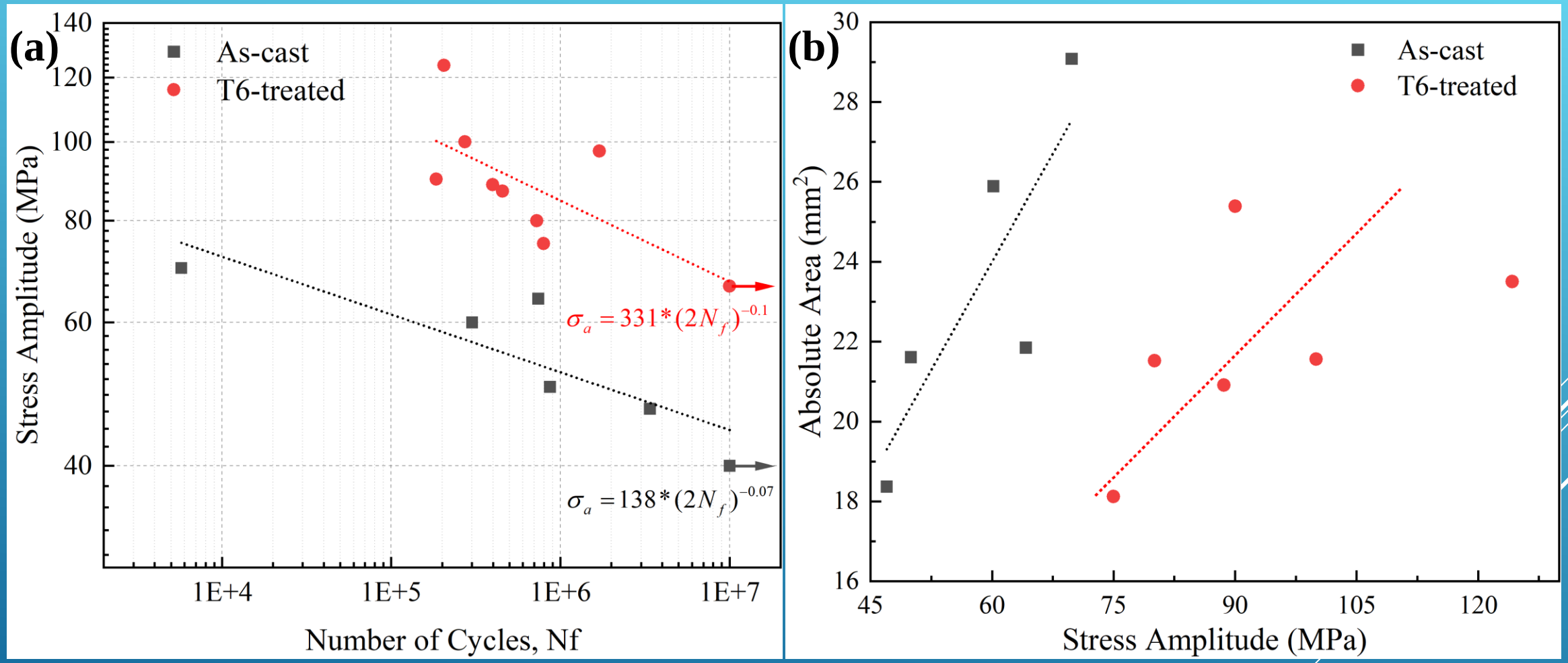

Fig. 7 Fatigue properties of (a) stress amplitude as a function of the number of cycles and (b) fast-fracture absolute area at various applied stresses for as-cast and T6 treatment of the A356-1Ce.

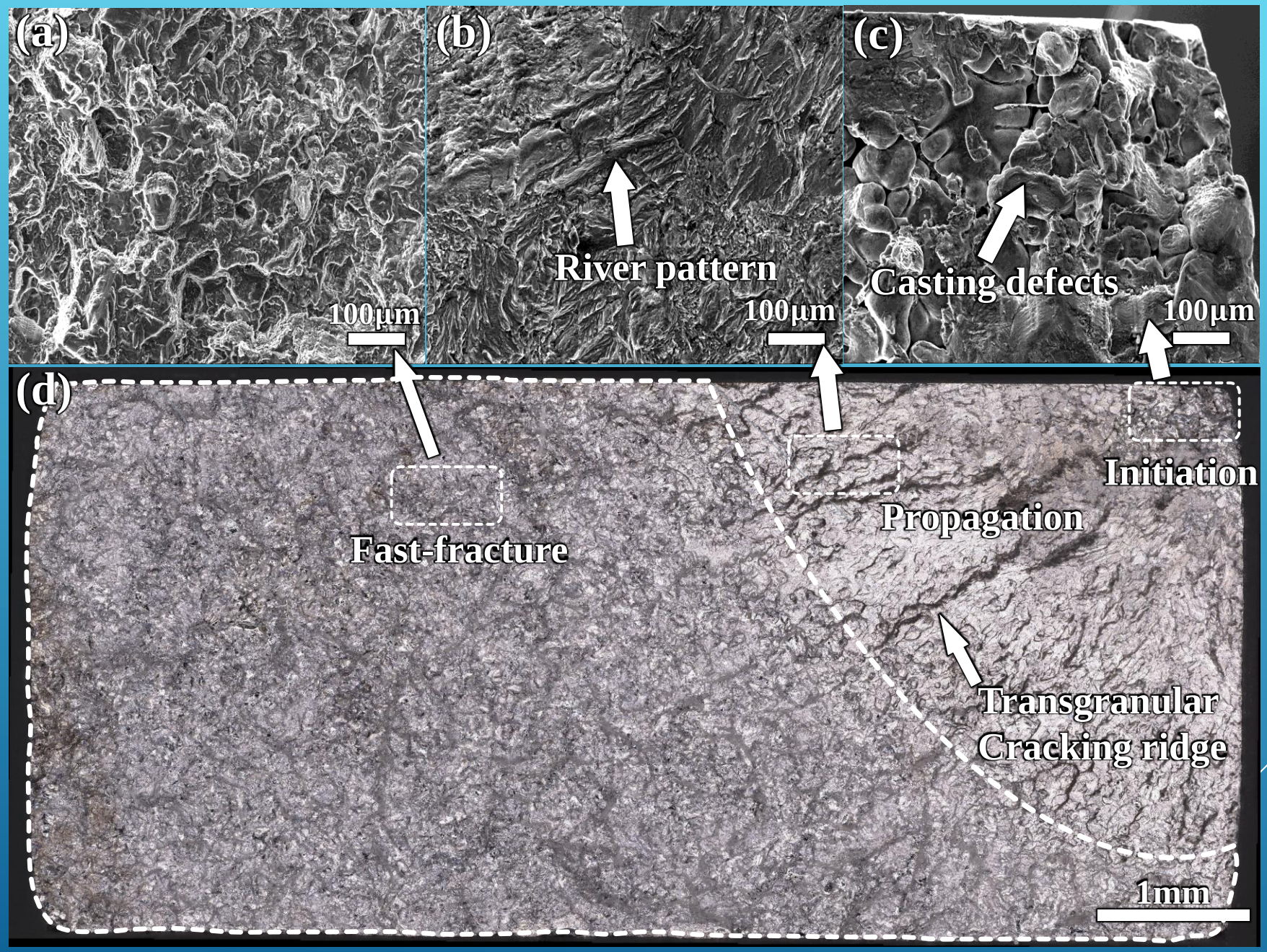

Fig. 8 Fatigue fractography of as-cast A356-1Ce sample at 65 MPa

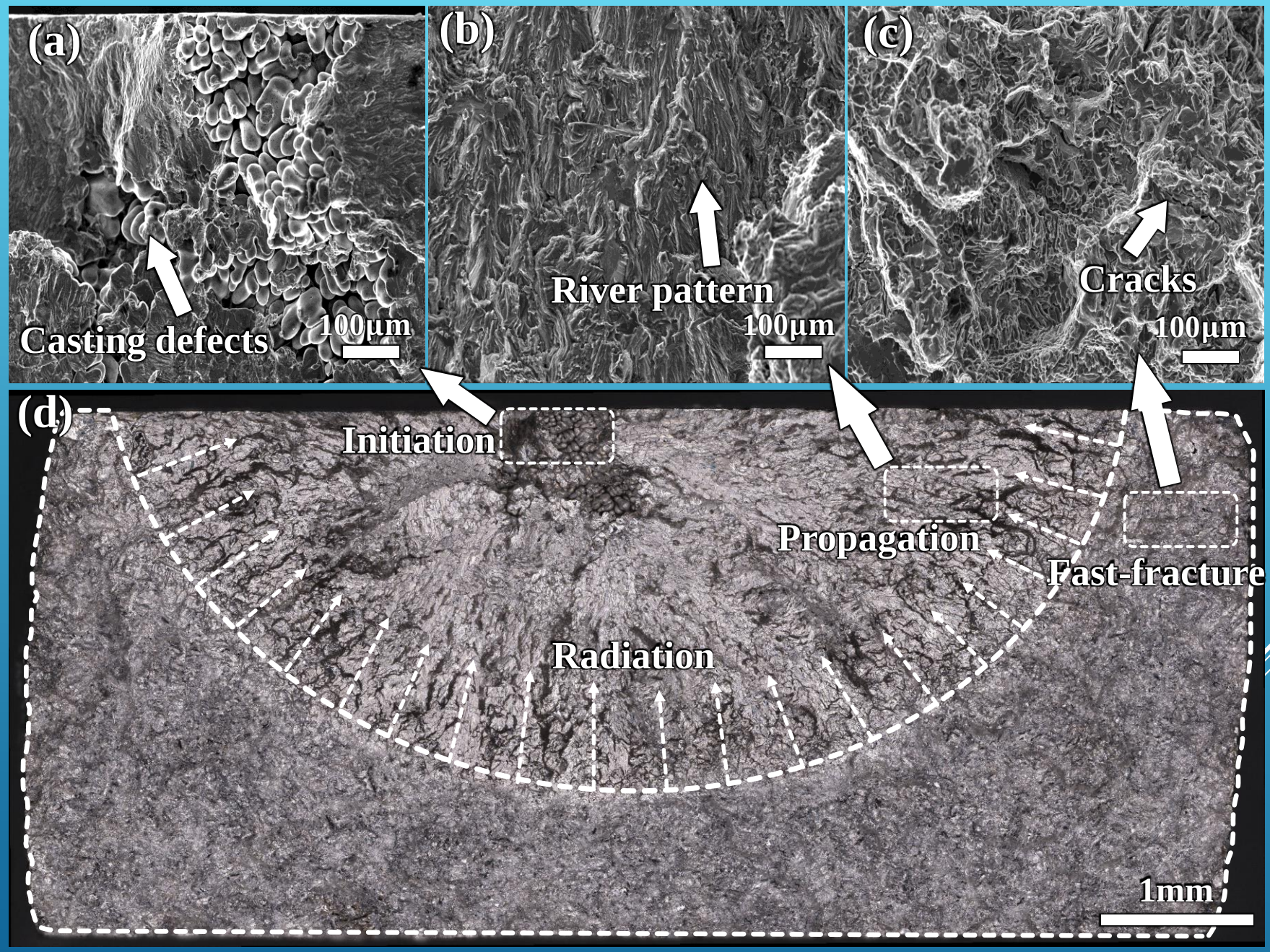

Fig. 9 Fatigue test fractography of T6-treated A356-1Ce sample at 90 MPa

Thank you !