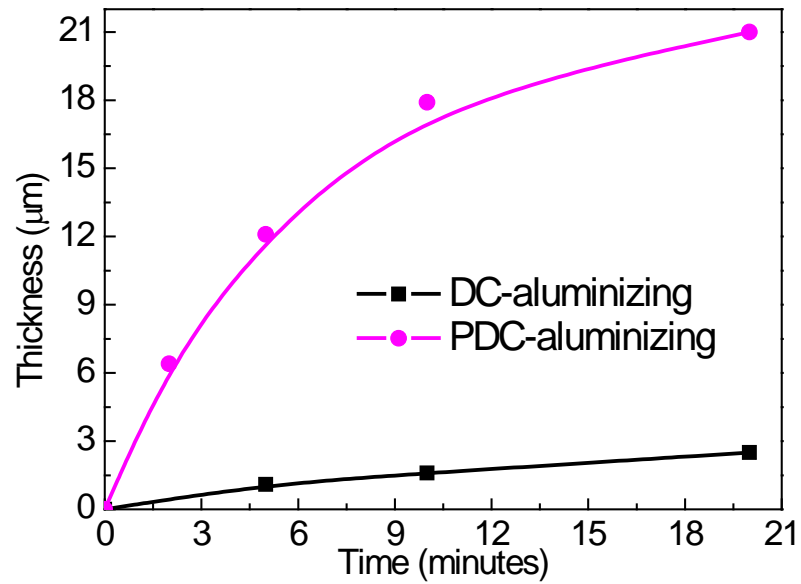
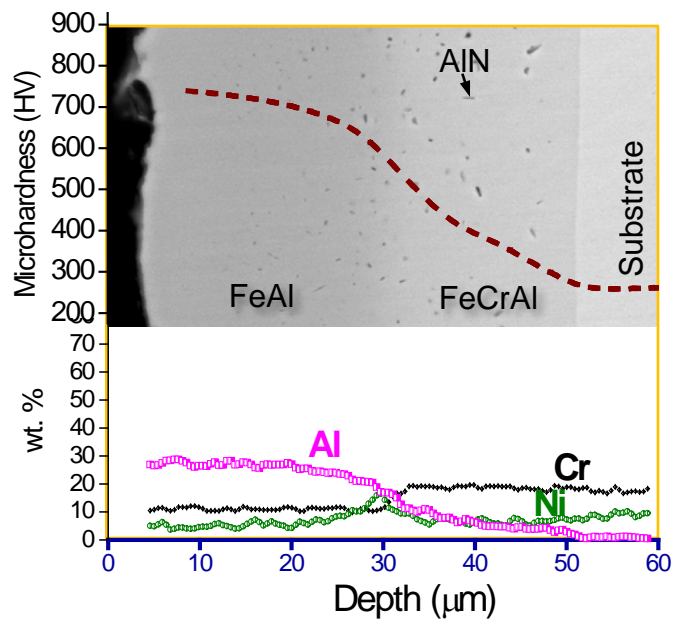


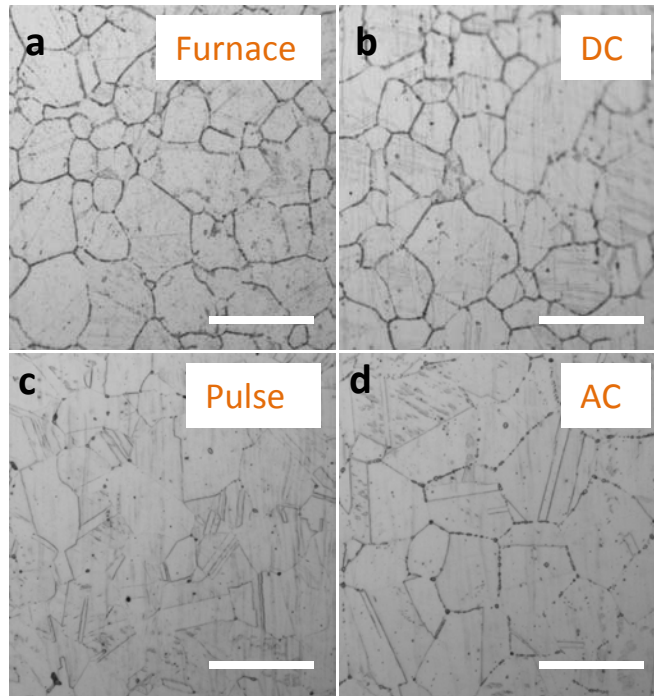
Supplementary Figure 1 | Conventional aluminizing. SEM image of the cross-section of the samples aluminized in furnace at 860 °C for 10 minutes, indicating that the microstructure of the aluminized layers is similar to that of the DC-aluminized sample. Scale bar, 10 μm .



Supplementary Figure 2 | Growth kinetics of β -FeAl layer. The growth kinetic curves for the growth of β -FeAl layer in DC- and PDC-aluminized samples.



Supplementary Figure 3 | Characterization of the AC-aluminized layer. SEM image, EDS composition and indentation depth profile of the cross-section of the aluminized layer after passing AC at 1200 A cm^{-2} for 10 minutes.



Supplementary Figure 4 | Metallographic examinations of the substrate after aluminizing. a, Furnace aluminizing (860 °C, 10 minutes), mean grain size: 18.3 μm , number of twin boundaries per unit length (twin density): 0.05 μm^{-1} . **b,** DC-aluminizing (1300 A cm^{-2} , 10 minutes), mean grain size: 19.4 μm , twin density: 0.07 μm^{-1} . **c,** PDC-aluminizing (1400 A cm^{-2} , 10 minutes), mean grain size: 19.4 μm , twin density: 0.09 μm^{-1} . **d,** AC-aluminizing (1200 A cm^{-2} , 10 minutes), mean grain size: 22.2 μm , twin density: 0.06 μm^{-1} . Scale bar, 50 μm .