

# FAILURE MOAD TRANSITION OF NBSS PHASE FROM CLEAVAGE TO DIMPLE IN NB-SI BASED ALLOYS PREPARED BY SPARK PLASMA SINTERING THROUGH CONTROLLING OF NBSS POWDER SIZE AND MORPHOLOGY AND ALLOYING

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The influence of Nb powder sizes and morphologies (equiaxed and flaky particles) on fracture toughness and fracture modes of Nb-16Si binary alloy and one multi-component Nb-16Si-22Ti-2Al-2Hf-7Cr alloy with an Nb/Nb<sub>5</sub>Si<sub>3</sub> microstructure fabricated by spark plasma sintering (SPS) was investigated. A reduced Nb powder size from 83.8 μm to 4.9 μm led to an Nb matrix with fine grain (9.9 μm in size) plus Nb<sub>5</sub>Si<sub>3</sub> islands two-phase microstructure, which changed the fracture mode of the Nb phase from cleavage (Fig. 1a) to a mixed mode of dimple (arrows A in Fig. 1b), tear (arrows B in Fig. 1b) and cleavage (arrows C in Fig. 1b), and then the fracture toughness of the Nb-16Si binary samples was significantly improved from 8.2 MPa·m<sup>1/2</sup> (Fig. 1a) to 12.4 MPa·m<sup>1/2</sup> (Fig. 1b). A further improvement of the fracture toughness to 15.8 MPa·m<sup>1/2</sup> was achieved in the multi-component Nb-16Si-22Ti-2Al-2Hf-7Cr alloy owing to full dimples (Fig. 1c) on the finer fractured Nb grains with a size of 11.2 μm through addition of the toughening elements of 22 at.% Ti and 2 at.% Hf. It is interesting that when the flaky Nb powders (123.7 μm in diameter and 15.2 μm in thickness) were used to prepare the Nb-16Si binary sample, the Nb grains still adopted the flake morphology and two fracture modes were observed in one fractured Nb grain, i.e., the cleavage mode in radial plane and the dimple or tear mode in axial plane of the flaky Nb grain (Fig. 1d). These kinds of fracture modes in one flaky Nb grain also improved the fracture toughness of the bulk Nb-16Si binary sample to 11.8 MPa·m<sup>1/2</sup> (Fig. 1d).

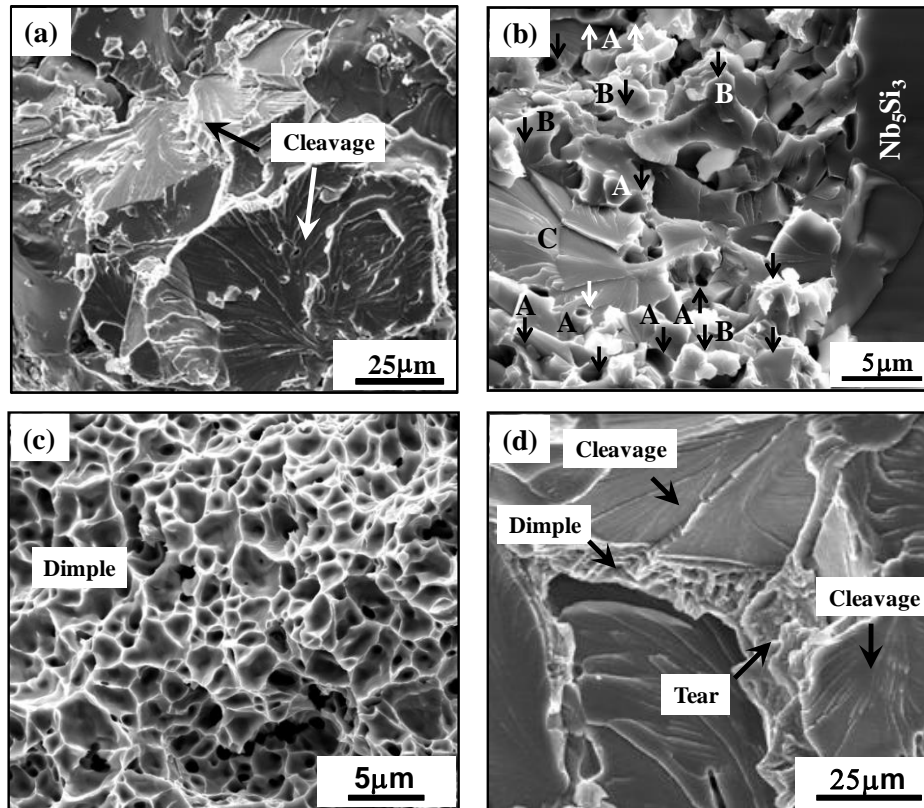


Figure 1. Fracture surfaces of samples after bending test. (a) Nb-16Si alloy with cleavage of Nb; (b) with cleavage, dimple and tear of Nb; (c) with full dimple of Nb<sub>SS</sub> and (d) with cleavage plus dimple and tear of Nb