Study of the tungsten coated stainless steels with ion beam mixing or electron beam alloying treatment

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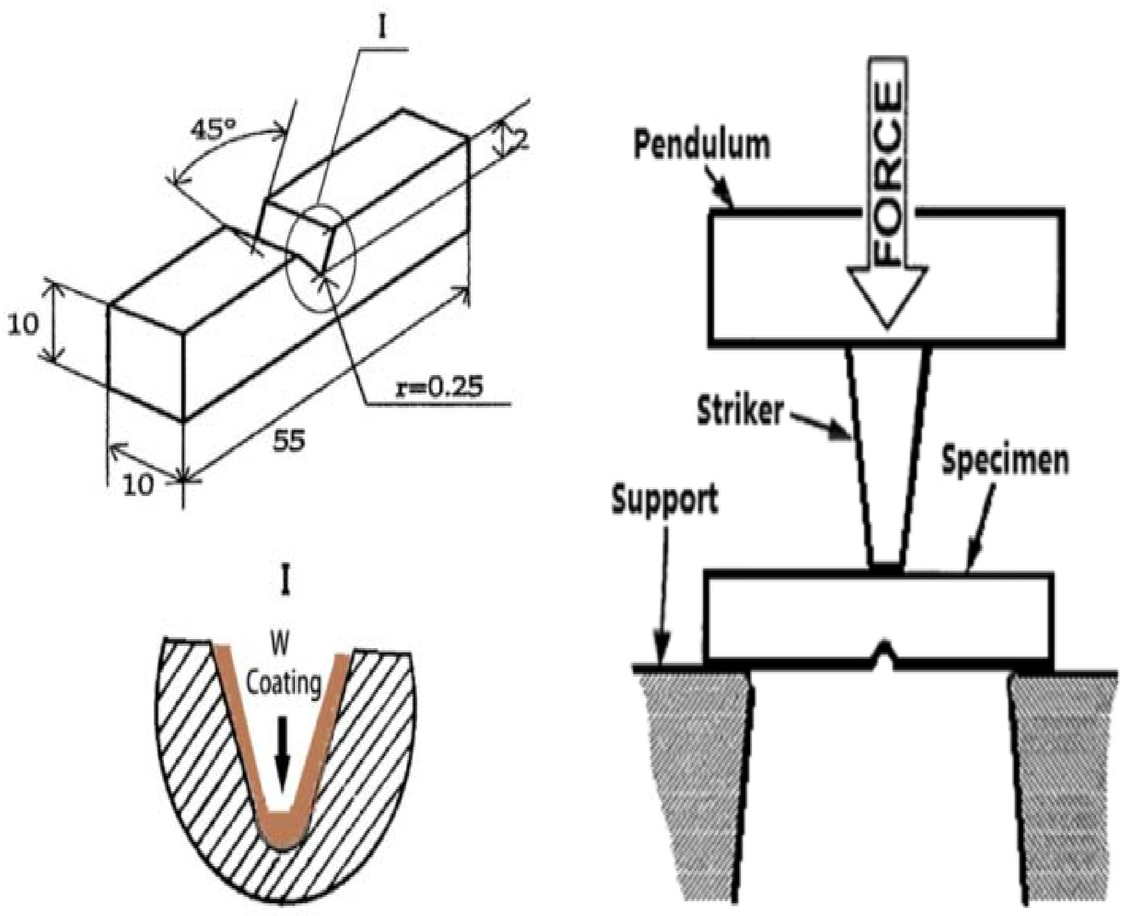


Fig.1.The Charpy V notched substrates made of stainless steel for instrumented impact test.

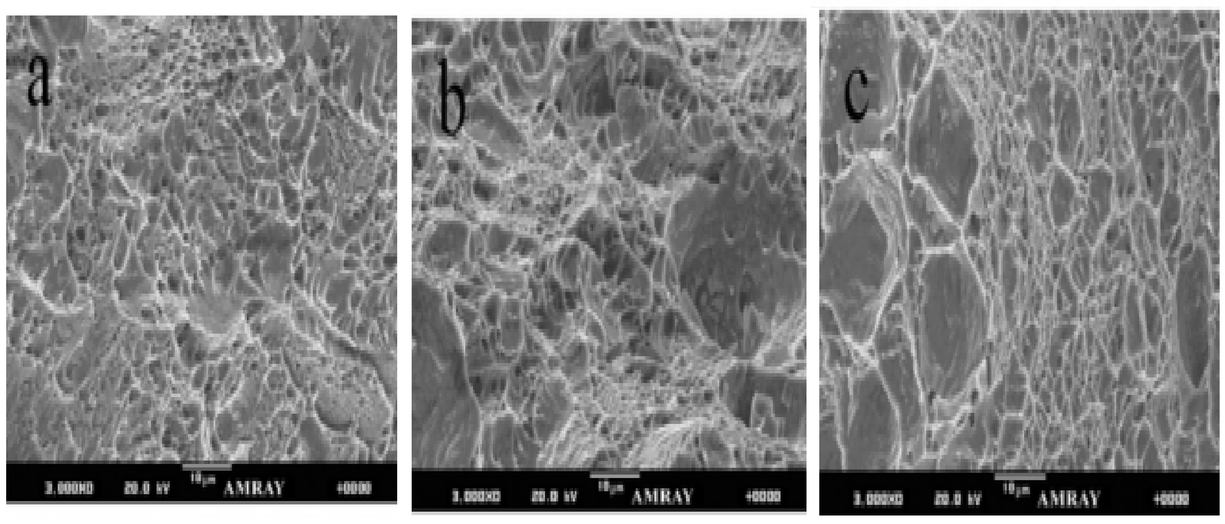


Fig.2. Fracture morphologies of the specimens at test temperature of -70℃: (a) stainless steel substrate without tungsten film (group I); (b) stainless steel coated tungsten films with IBM (group II); and (c) stainless steel coated tungsten films with EBA (group III).

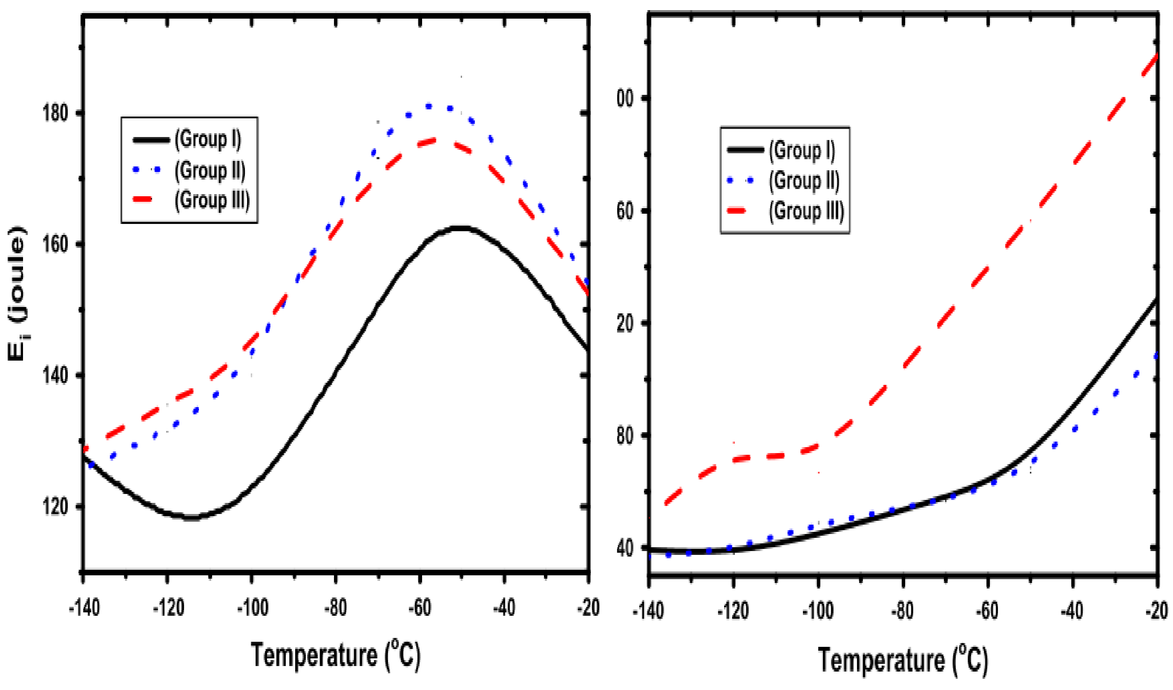
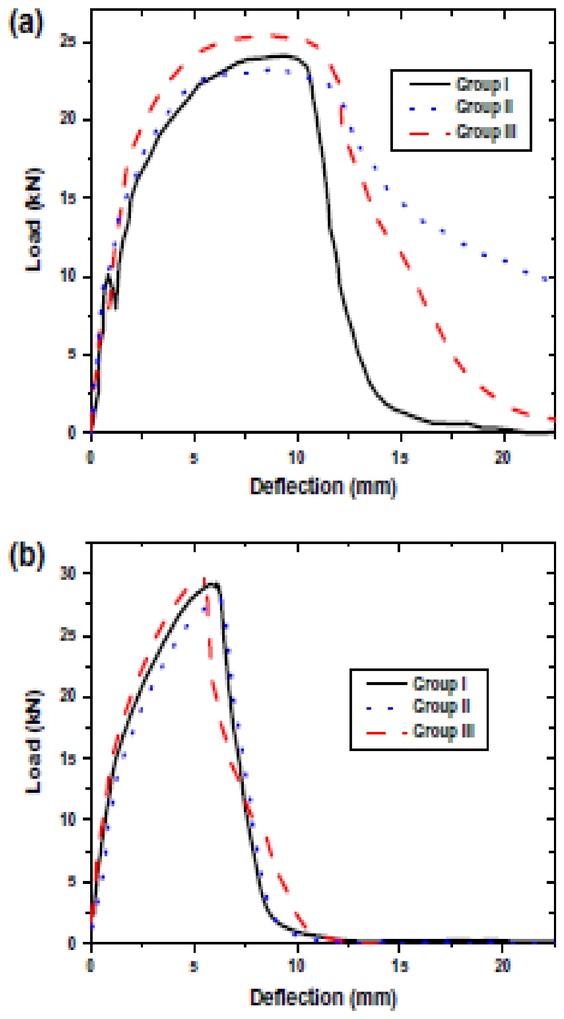


Fig.3. Crack initiation energy (left) and crack propagation energy (right) vs. test temperature T.



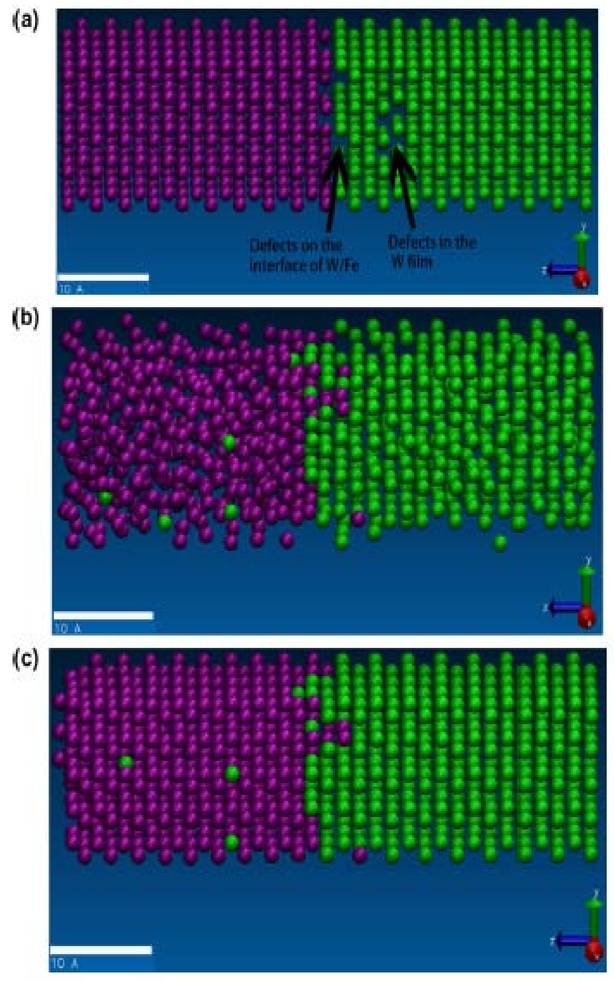


Fig.4. Left: recorded curves of the instrumented impact test for samples at: (a) -50℃, and (b) -140℃; Right: molecular simulations of W coated Fe crystal (a) before EBA, (b) after EBA, and (c) after quenching.

We study the impact properties of a W coated SS under a shock of outside force. The tungsten films were deposited on stainless steel (SS) by using magnetron sputtering, and combined with ion beam mixing (IBM) or electron beam alloying (EBA) treatment. The ductile–brittle transition behaviors of the specimens were investigated by means of instrumented Charpy impact test at a series of temperature, and SEM was used to observe the morphology of the cross section.

The microstructural transaction near the interface of W and SS during IBM or EBA treatment was simulated by using molecular dynamics. Comparing the microstructures of W films treated with IBM or EBA, it can be found that IBM cause amorphization with defects or vacancy in W films, while the EBA treatment heals the defects in the body of W films.

The W coated SS with EBA treatment shows a remarkably stronger increase of fracture toughness than W film coated SS treated with IBM. The IBM treated W films shows amorphous structure, while the EBA treatment not only result in crystallization W films but also cause a migration of defects from the body to the surface of the W film. The reason that the IBM treated W film showing worse fracture toughness could be attributed to the defects such as vacancy in the films which leads to missing bonds and lattice distortion.

Reference:

1,Y. Zou, C.-Y. Zhan, B. Yang, J.-C. Wu, J. Nucl. Mater. 436, 56-60, 2013.