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THE STRESS INDUCED MARTENSITE-AUSTENITE INTERFACE IN Fe-15Ni-15Cr SINGLE CRYSTALS

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THE STRESS INDUCED MARTENSITE-AUSTENITE INTERFACE IN Fe-15Ni-15Cr SINGLE CRYSTALS

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A single crystal stressed in the $[\bar{2}\bar{1}3]\gamma$ direction at 185°K was transformed to 5% α martensite and 2% ε martensite by volume. The austenite slip system of maximum shear stress is the $(\bar{1}11)\gamma$ $[01\bar{1}]\gamma$. Fig. 1 shows a two surface study using the electron and optical microscopes. The α martensite is confined between ε martensite plates with the $(0001)\varepsilon \parallel (\bar{1}11)\gamma$. The size of the acicular martensite crystals is controlled by the spacing of the ε martensite plates. These ε martensite plates are seen in Fig. 1A as dark vertical bands. The axes of the acicular crystals lie in the $(\bar{1}11)\gamma$ plane. The ε martensite habit plane is defined as the plane perpendicular to the $(\bar{1}11)\gamma$ containing the vector defining the crystal axis.

Measurements of the acicular crystal axis was made from optical micrographs using the trace of an ε plate on the $(11\bar{1})\gamma$ plane cutting the $(\bar{1}11)\gamma$ in the $[101]\gamma$ direction as a crystallographic reference. The results that follow are in the form of unit vectors and represent the average of no less than six independent measurements. The experimental error is estimated to be ±0.25°. Typical variation in the axis of α martensite crystals with seemingly the same crystallographic direction was ±1°. This variation is real and not due to experimental error. Results of the martensite crystal axis and the habit plane normal are given below:

Martensite Crystal Axis			Habit Plane Normal		
0.63433004	-0.12805297	0.76238300	0.51409345	0.80639265	-0.29229920
0.74554175	0.08445573	0.66108602	0.33291765	0.81211692	-0.47919927
0.10843235	0.75505982	-0.64662748	0.80926454	0.31072710	0.49853744
0.07606209	-0.66600086	0.74206295	0.81294602	0.47234471	0.34060131

The physical nature of the interface is being revealed in some detail working with $(01\bar{1})\gamma$ foils. Fig. 2A is a bright field micrograph showing a α martensite crystal cutting the surface with its axis a few degrees out of the plane of the foil. Fig. 2B is a dark field of the same area using a $(01\bar{1}1)\varepsilon$ reflection. Fine lines light up in the interface defining a sheath surrounding the α martensite. Fig. 2C is the $(200)\gamma$ reflection that lights up the sheath as well, indicating the α martensite crystal is surrounded by alternate regions of faulted austenite and dislocated austenite. Fig. 2D is the diffraction pattern from the same area and clearly shows this alloy obeys the Kurdjumov-Sachs orientation relationship. Specifically in this diffraction pattern the $(01\bar{1})_\gamma \parallel (\bar{1}11)_\gamma \parallel (\bar{2}110)_\varepsilon$ and $[\bar{1}11]_\gamma \parallel [110]_\alpha \parallel [0001]_\varepsilon$.

Efforts to image interface dislocations have been unsuccessful to date. It appears clear that the interface between the phases in this alloy is a composite of dislocated austenite and faulted austenite giving rise to hcp reflections. Also the $(110)\alpha$ surface of the crystal is in contact with and parallel to the $(0001)\varepsilon$ plane. The large very thin ε plates appear to control the size of the acicular α crystals and forces the long axis of the crystals to remain parallel to the austenite slip plane which is the $(\bar{1}11)\gamma$ in this example.

This work was performed under the auspices of the United States Atomic Energy Commission.

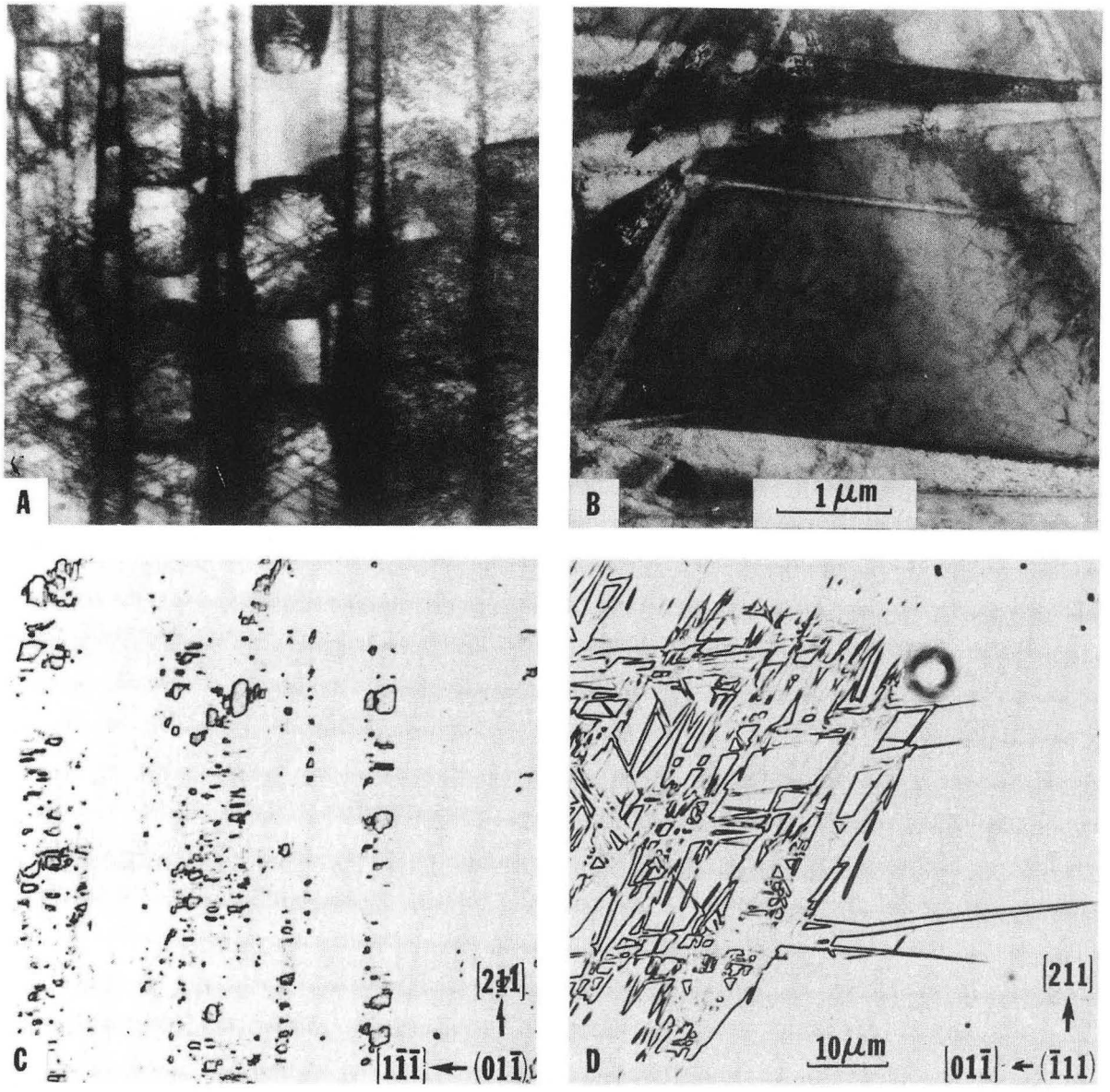

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Fig. 1. Two surface study of the (01$\bar{1}$)γ and ($\bar{1}$11)α planes using the electron microscope A and B, and optical microscope C and D.

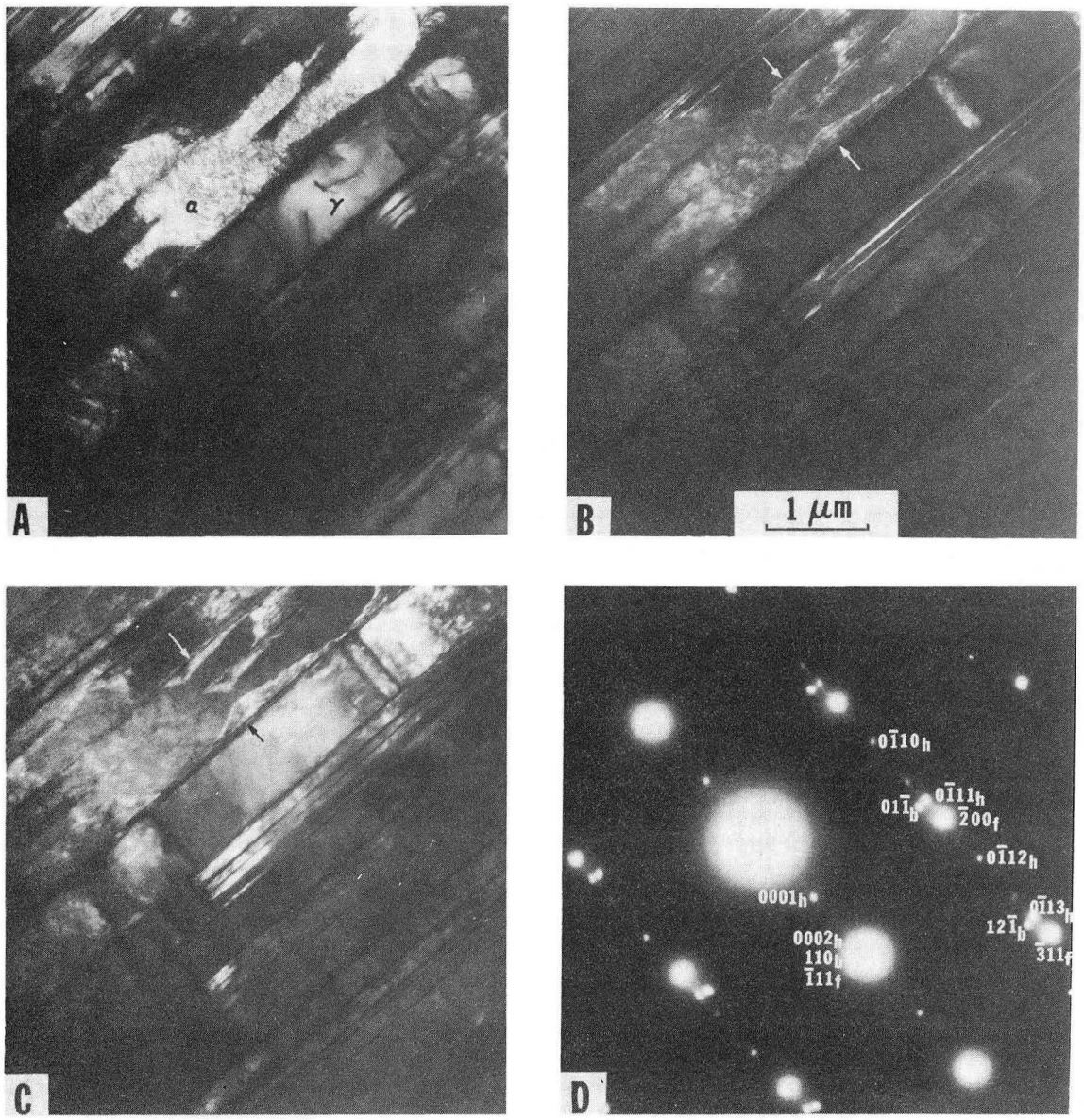

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Fig. 2. Structure of the martensite interface. Bright field image A, $(01\bar{1}1)\varepsilon$ reflection B, $(200)\gamma$ reflection C, and diffraction pattern D.

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