Some Remarks on "Mechanism of Formation of Lined-up \( V_4C_3 \) Precipitates in Low Carbon Vanadium Steels"*

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Suzuki and Tanino\(^1\) suggested that the origin of lined-up \( V_4C_3 \) particles in low carbon vanadium steels lies in dislocations introduced by the \( r\to\alpha \) transformation.

As discussed by the authors, many investigators\(^2\text-}^4\) have recently concluded that the rows are formed at the \( r/\alpha \) interface in connection with the decomposition of austenite. To support this theory the author would like to make the following remarks on the theory presented by Suzuki and Tanino.

If dislocations were nucleation sites for the rows there should be plenty of dislocations in the structure because the rows are, as a rule, very densely distributed. However, very few dislocations are found in a normalized structure, for example. And even the existing dislocations are generally not straight and parallel to each other but rather curved and irregularly distributed.

It is likely that the number of the dislocations generated in connection with the \( r\to\alpha \) transformation should decrease with decreasing cooling rate. However, according to the results obtained by the author,\(^5\) well developed rows are found also in structures formed during a very slow cooling through the \( r\to\alpha \) transformation. An example of such a structure is shown in Fig. 1. As can be seen, the rows are actually two-dimensional layers. The few dislocations which appear in the structure are not on the rows but rather normal to them obviously showing the direction of the movement of the \( r/\alpha \) interphase in the \( r\to\alpha \) transformation. It is unlikely that these dislocations have played main role in the formation of the rows.

Long dislocation trails (shown e.g. in Photo. 3 in the paper of Suzuki and Tanino) can hardly be nucleation sites for the lined-up particles, at least for all of them, firstly because they are found rarely, and secondly because they occur mostly in structures formed during relatively rapid cooling. In the author's experiments\(^6\) trails were rarely found in the same areas as the rows. In addition, if the lined-up particles were nucleated at the trails their distribution should be quite different from that seen in Fig. 1. This can be concluded from the dark-field micrograph shown in Fig. 2, where the trails appear light. In this particular case the trails are very straight.

Dislocations in ferrite adjacent to the martensitic areas have obviously been generated during quenching as a result of \( r\to\alpha' \) transformation stresses and, thus, they possibly have not been present at all during the formation of the rows.

The fact that the rows very often are at large angles with respect to the prior austenite grain boundary is not necessarily an evidence against the theory that the rows were formed at the \( r/\alpha \) interface. The rows merely delineate the former positions of the \( r/\alpha \) interface.

The suggestion that the \( V_4C_3 \) particles forming rows precipitate in the proeutectoid ferrite immediately after the beginning of the \( r\to\alpha \) transformation does not completely agree with the observation that during tempering \( V_4C_3 \) precipitates grow rather slowly to a clearly observable size.\(^6\)

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The spacing between successive rows does not depend on the decomposition temperature only, even if the rows are formed at the $\gamma/\alpha$ interface. Other factors, such as the actual carbon content or precipitates and inclusions in austenite may affect the migration kinetics of the $\gamma/\alpha$ interphase and thus cause local changes in the spacings between the rows.

The arguments in favor for the statement that rows intersect with each other in some places are not wholly indisputable. The micrograph (Photo. 5 in the paper of Suzuki and Tanino) elucidating row intersections is taken from a specimen treated isothermally for 100 hr at 600°C. However, well developed rows are mainly formed at higher temperatures, rather in the range of 650°C to 770°C. In addition, during a long holding at 600°C the precipitate distribution may have changed. It should also be noted that if the rows were formed by the mechanism suggested, row intersections should be very common. However, in author’s experiments they never occurred.

In the author’s opinion, the experimental observations give more support to the theory according to which the rows are formed at the repeatedly moving $\gamma/\alpha$ interface and less support to the theory suggested by Suzuki and Tanino.

REFERENCES