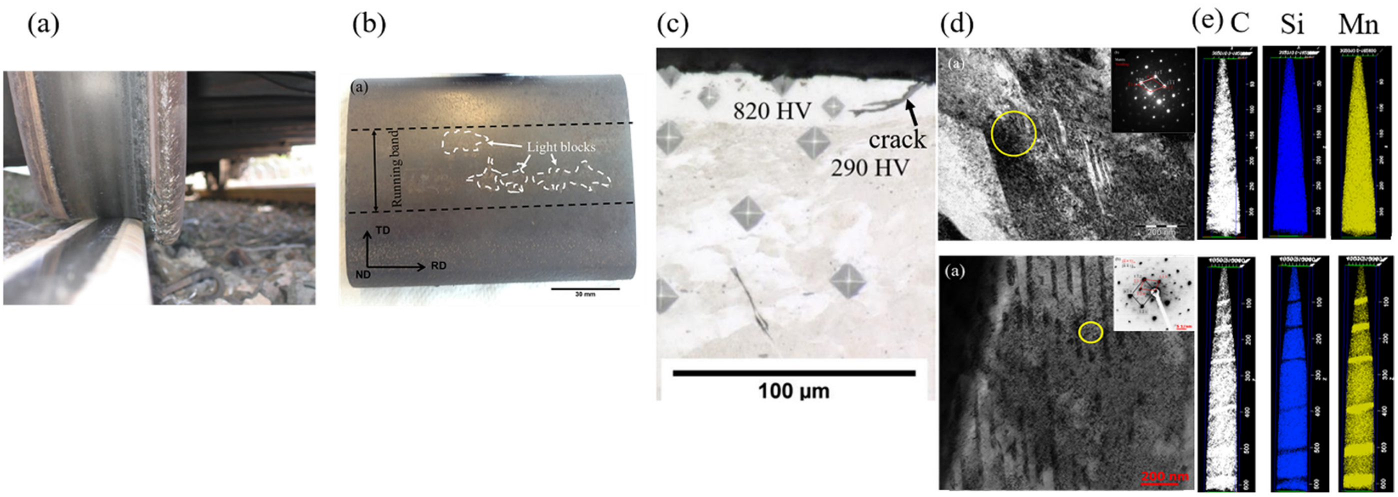
What really happens inside railways....

Each year, ProRail has to spend several million euros on periodic and ad-hoc maintenance work on railway tracks, in order to remove fatigue cracks before they lead to catastrophic rail fracture. One of the widely considered causes for the fatigue damage, which in railways applications occurs as Rolling Contact Fatigue (RCF), lies in the changes in the internal structure of the steel that are induced during the passage of trains: so-called white etching layers (WEL) form. The extremely high hardness of the WEL is considered to be the origin of its susceptibility to fracture and crack formation during the subsequent loading by passing train wheels. Until now, the prevalent models used to describe the RCF process in rails fail to predict the occurrence of the WEL, due to the fact that the origin and character of the WEL remained debatable.



Railway steel at different length scales. From left to right: (a) macroscopic view of the rail/wheel contact at the metre scale; (b) signs of WEL formation at the rail surface, seen at the millimetre scale; (c) microscopic cross-section of railway steel, where the hard (820 HV Vickers hardness) WEL, as well as a fatigue crack, is visible at the top at the micrometre scale; (d) nano-twins and cementite traces in the WEL's martensite at the nanometre scale; (e) distribution of alloying elements C, Si and Mn at the nanometre scale, with the WEL in the top three pictures and the original steel in the bottom three

Dr. Jun Wu explores, together with prof. dr.ir. Jilt Sietsma and prof.dr.ir. Roumen Petrov, the root cause of the WEL formation via a series of microstructure characterizations, laboratory simulations, and theoretical modelling. The microstructural study, combining a wide variety of modern microscopy techniques, leads to the unambiguous conclusion that the WEL forms due to the significant heat generated during the wheel passages. The microstructure changes show that underneath train wheels the temperature repeatedly increases to over 700 °C. The WEL structure was successfully reproduced under well-controlled laboratory conditions mimicking this rapid temperature rise followed by fast cooling. Furthermore, the characteristics of the WEL formation process were studied by phase field modelling. The insight provided by the thesis work of Jun Wu provides important guidance for the future design of new rail steels with higher resistance against WEL formation.

The Ph.D. research work of Jun Wu was performed under the joint supervision of Delft University of Technology and Ghent University. Jun Wu succeeded in defending his thesis first at Ghent University on 7 November 2018 and later, on 17 December 2018, at Delft University of Technology. This entitles him a joint degree from both universities. The title of his thesis is 'Microstructure Evolution in Pearlitic Rail Steel due to Rail/Wheel Interaction'.

The thesis can be found at: https://repository.tudelft.nl/islandora/object/uuid%3Ac536ca47-8981-4a9e-916f-396bcbca4bc5