



## Superstærk ståltråd med mikrostruktur på nanoskala

Hansen, Niels; Zhang, Xiaodan; Huang, Xiaoxu; Godfrey, Andrew

*Publication date:*  
2012

[Link back to DTU Orbit](#)

*Citation (APA):*

Hansen, N., Zhang, X., Huang, X., & Godfrey, A. (2012). *Superstærk ståltråd med mikrostruktur på nanoskala*. Abstract fra Dansk Metallurgisk Selskabs Vintermøde 2012, Rebild Bakker, Danmark.

---

### General rights

Copyright and moral rights for the publications made accessible in the public portal are retained by the authors and/or other copyright owners and it is a condition of accessing publications that users recognise and abide by the legal requirements associated with these rights.

- Users may download and print one copy of any publication from the public portal for the purpose of private study or research.
- You may not further distribute the material or use it for any profit-making activity or commercial gain
- You may freely distribute the URL identifying the publication in the public portal

If you believe that this document breaches copyright please contact us providing details, and we will remove access to the work immediately and investigate your claim.

# Superstærk ståltråd med mikrostruktur på nanoskala

Niels Hansen <sup>a</sup>, Xiaodan Zhang <sup>a,b</sup>, Xiaoxu Huang <sup>a</sup>, Andrew Godfrey <sup>b</sup>

<sup>a</sup> Danish-Chinese Center for Nanometals, Section for Materials Science and Advanced Characterization, Dept. for Wind Energy, Risø Campus, Technical University of Denmark, DK-4000 Roskilde, Denmark

<sup>b</sup> Advanced Materials Laboratory, Department of Materials Science and Engineering, Tsinghua University, 100084, PR China

Strengthening mechanisms and strength–structure relationships have been analyzed in a cold-drawn pearlitic steel with a structural scale in the nanometer range and a flow stress of about 3.5 GPa. The wires have been drawn up to a strain of 3.7 and the structures analyzed and quantified by transmission electron microscopy and high resolution electron microscopy. The mechanical properties have been determined by tensile testing. It is found that the interlamellar spacing and the thickness of the cementite lamellae are reduced in accordance with the changes in wire diameter up to a strain of 2.5. At a higher strain enhanced thinning of the cementite lamellae points to decomposition of the cementite and carbon enrichment of the ferrite lamellae. Dislocations are stored in the interior of the ferrite lamellae and their density increases to about  $2 \times 10^{16} \text{ m}^{-2}$ . A high dislocation density is also observed at the ferrite/cementite interface. Three strengthening mechanisms have been analyzed: (i) boundary strengthening, (ii) dislocation strengthening and (iii) solid solution hardening. The individual and combined contributions, based on an assumption of linear additivity, of these mechanisms to the wire strength have been estimated. Good agreement has been found between the estimated and the measured flow stresses, which is followed up by a discussion of structure and strengthening mechanisms with a view to extrapolation to larger strains, finer structures and larger stresses.

## Acknowledgements

The authors thank NV Bekaert SA Technology Center Laboratory (Zwevegem, Belgium) for the supply of the pearlitic steel wires used in this investigation. The authors gratefully acknowledge the support from the Danish National Research Foundation and the National Natural Science Foundation of China (Grant No. 51261130090) to the Danish-Chinese Center for Nanometals, within which this work has been performed.

## References

1. Xiaodan Zhang, Andrew Godfrey, Xiaoxu Huang, Niels Hansen, Qing Liu. Microstructure and strengthening mechanisms in cold-drawn pearlitic steel wires. *ACTA MATERIALIA*, 2011, 59, 3422-30.
2. Xiaodan Zhang, Andrew Godfrey, Niels Hansen, Xiaoxu Huang, Wei Liu, Qing Liu. On The evolution of cementite morphology in a pearlite steel wire during wet wire drawing. *MATERIALS CHARACTERIZATION*, 2010, 61, 65-72.
3. Xiaodan Zhang, Andrew Godfrey, Wei Liu, Qing Liu. Study on dislocation slips in ferrite and cementite deformation in cold-drawn pearlitic steel wire from medium to high strain. *MATERIALS SCIENCE AND TECHNOLOGY*, 2011, 27, 562-7.
4. Xiaodan Zhang, Andrew Godfrey, Xiaoxu Huang, Niels Hansen, Wei Liu, Qing Liu. Characterization of the microstructure in drawn pearlitic steel wires. *Risoe International Symposium on Materials Science. Proceedings 30*, 2009. p. 409-416.