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University of Oldenburg, Germany

## Dilemma between ISO and physics in (nano) indentation

**S** ince 2000, it is experimentally found and since 2015, physically deduced that pyramidal/conical nanoindentations follow the law of normal force  $F_N = k \cdot h^{3/2}$  but not constant  $h^2$  (h=indentation depth). However, the unsupported exponent 2 is still used by the ISO-14577 standard, that industry and government must obey, while it does not concur with physics. Also NIST (2009) continued using  $h^2$  for defining erroneous mechanical parameters in a tutorial, despite their curves supporting  $h^{3/2}$ . Only the precisely validated k and  $h^{3/2}$  allow for a wealth of otherwise unachievable characterizations, such as initial surface effects, gradients, phase transitions, transformation energy and activation energy. Arithmetically,  $h^{3/2}$  reveals the 80/20 ratio of indentation- and long-range works, independent of material or method. Unfortunately, also ISO hardness and elastic modulus depend on false  $h^2$ , and the differences between  $h^2$  and  $h^{3/2}$  are very large. Thus, present mechanical data from indentations create dilemma between ISO standards and physics. It is however possible to obtain the "physical hardness" solely from the penetration resistance k of the loading curve. All deduced mechanical parameters from indentations are in error when depending on  $h^2$  instead of  $h^{3/2}$ . Miscalculated materials and composites against physics might be the reason for medical or technical failures even growing to disasters. How shall liabilities in these cases be judged and compensated? 50 years published data require the original data or at least loading curves to be corrected for the sake of daily safety.

## **Biography**

Gerd Kaupp has completed his PhD from Würzburg University and Post-doctoral studies from Iowa State, Lausanne, and Freiburg University. He has privately continued his research on "AFM on rough surfaces". He has published more than 300 papers in renowned journals and has been serving as an Editorial Board Member of several scientific journals.

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