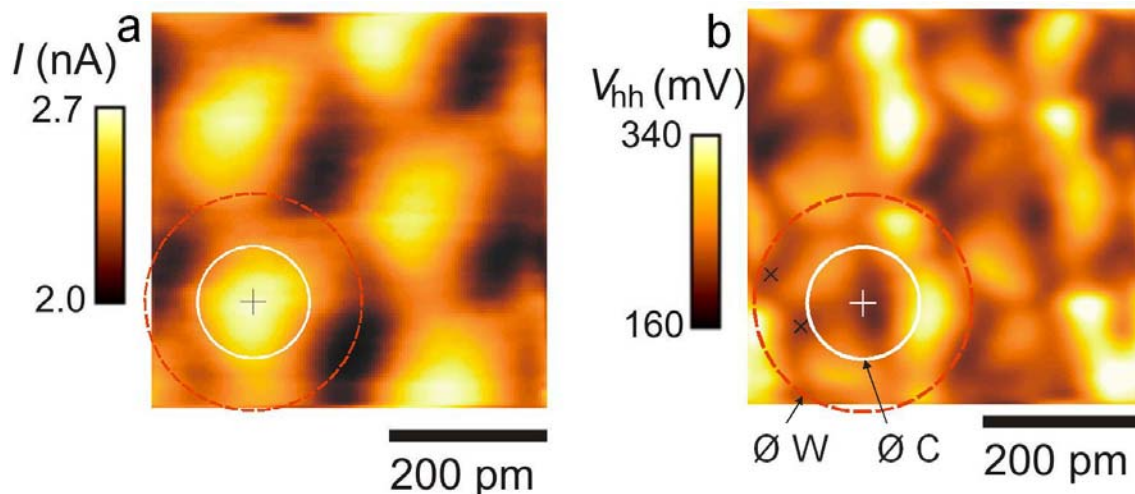


Sub-Å resolution by force microscopy

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In contrast to the elementary picture of metallic bonds, transition metals display a partially covalent bonding character with pockets of increased charge density located between adjacent atoms. We image these charge distributions with a modified atomic force microscopy technique that analyzes higher harmonics of the oscillation amplitudes. The analysis of the higher harmonics has first been proposed by Dürig [1] who found that the complete interaction potential can be recovered from the amplitudes and phases of higher harmonic cantilever amplitudes. In addition, it can be shown that higher harmonics directly couple to higher derivatives of the forces between individual atoms with respect to distance and thus provide a signal that is more sensitive to short-range force components. The new technique enables a leap in resolution and permits to image charge distributions in single surface atoms of tungsten with a lateral spacing of 77 pm [2]. These spatially confined charges reflect the covalent bonding character in transition metals.



The figure shows simultaneously recorded constant-height images of graphite (HOPG) using a tungsten tip. The tunneling current is shown in a), the higher harmonics of the oscillation amplitudes are shown in b). The distance between the two black crosses in b) is 77 pm, the center of the four lobes indicated by a white cross in b) coincides with the bottom left current maximum in a). The dashed red circle shows the diameter of a tungsten atom, the white circle indicates the diameter of a carbon atom.

[1] U. Dürig, *New Journal of Physics* **2**, 5.1-5.12 (2000).

[2] S. Hembacher, F.J. Giessibl, J. Mannhart, *Science*, in press, online at Science express June 10 2004.