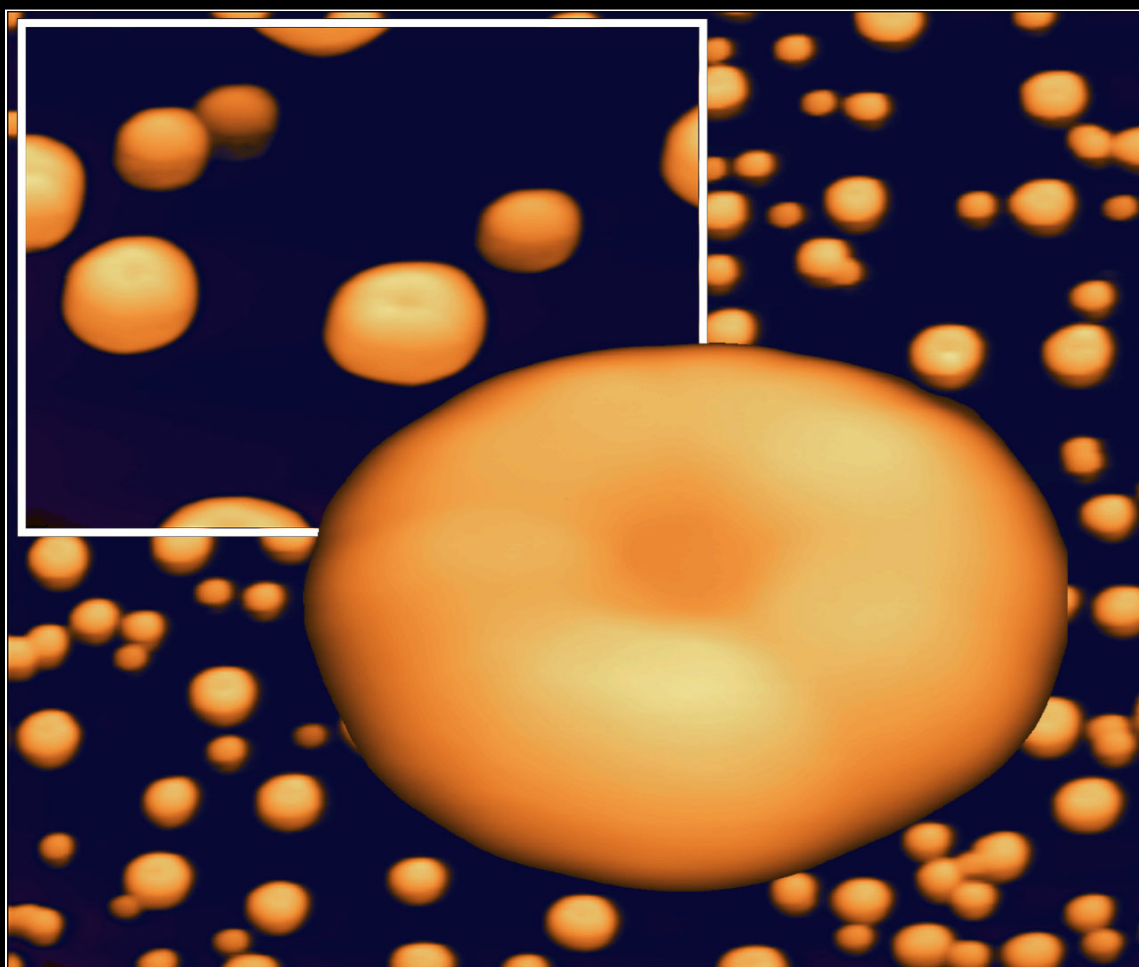# Nanodonuts

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Recipe. Deposit catalytic nickel nanoparticles onto a thoroughly washed polished baking tray of single-crystal silicon. Use only well-refined nickel of the first-class domestic brands. Perform the deposition in a glow-discharge oven for several minutes continuously adding small amounts of the noble gas argon. Put the obtained nanoparticles into a microwave oven, let in a mixture of methane, argon, and hydrogen. Bake nanodonuts within 20 minutes.

The synthesis of carbon nanostructures in the form of nanodonuts (nanotori) was implemented on the Diamond system (collaborative development of the Institute of Physical Problems named after F. V. Lukin and the Institute of Precise Mechanical Engineering, Russia) by plasma-enhanced chemical vapor deposition method. During the catalytic nickel nanoparticle deposition, a high-purity nickel foil (99.99%, Lab-3, Russia) was used as the target. Due to high catalytic reactivity of the nickel nanoparticles, the temperature of the synthesis process was decreased from 750°C to 150°C. Polished silicon wafer was used as the substrate. The images of the nanodonuts were obtained on the atomic-force microscope Smena™ HV (NT-MDT Co., Russia) in ambient environment in tapping mode. A silicon microcantilever with a probe of 10 nm approx. curvature radius (Institute of Physical Problems named after F. V. Lukin, Russia) was used for the scanning. In the background, the obtained carbon nanostructures are shown in two scales: 5×5 µm² and 20×20 µm². Outer diameter of the nanodonuts equals to 430-960 nm, inner diameter 80-230 nm, height 90-160 nm. In the foreground, the nanodonut image taken with high magnification is presented.

The experimental results were obtained with the active participation of the researchers from the Institute of Physical Problems named after F. V. Lukin: postgraduate Pavel V. Azanov, Prof. Eduard A. Ilyichev, Dr. Georgiy N. Petruhin, postgraduate Leonid L. Kupchenko. The author is grateful to software developer Oleg E. Lyapin for help in preparation of this artwork.