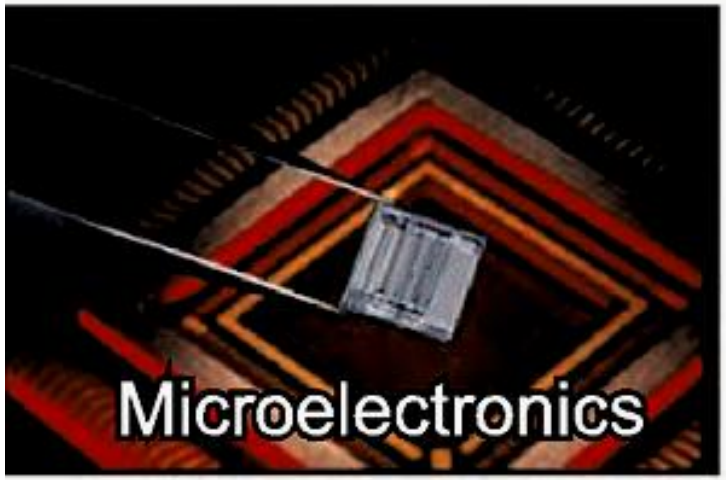
Institute of Advanced Materials and Technologies
National Research University of Electronic Technology - MIET

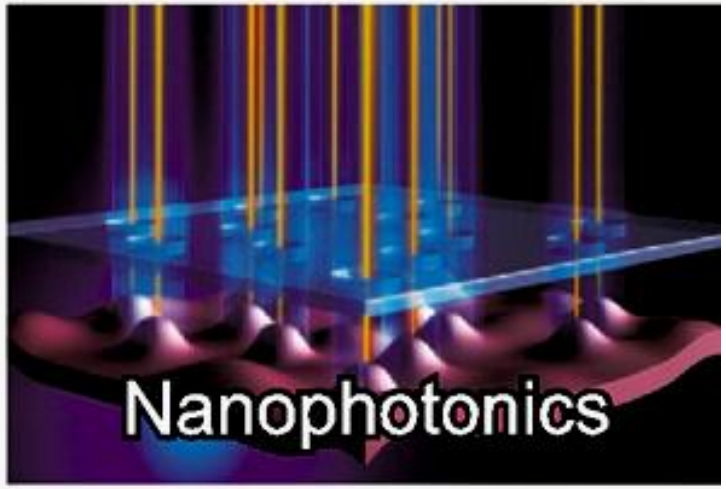
Nano Innovation 2020
Rome, 15-18 September
Conference & Exhibition

New nanomaterials and heterostructures for energy applications

Presenter: Dronov Alexey
Dronov.Alexey@org.miet.ru

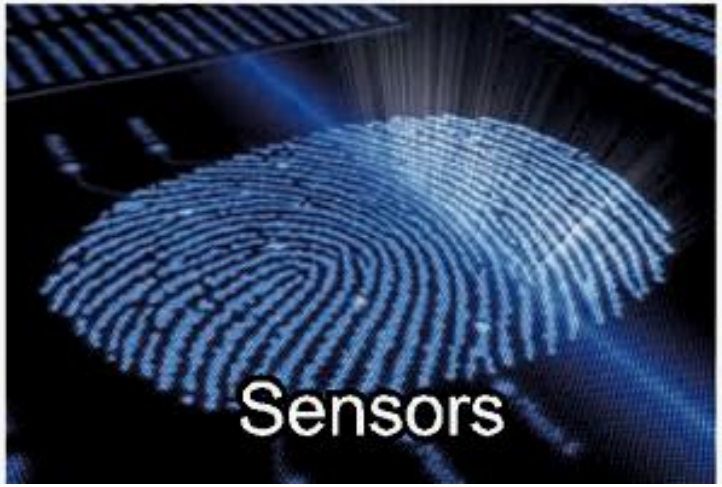

Microelectronics


High-tech materials
for new electronics
and power engineering


Nanophotonics

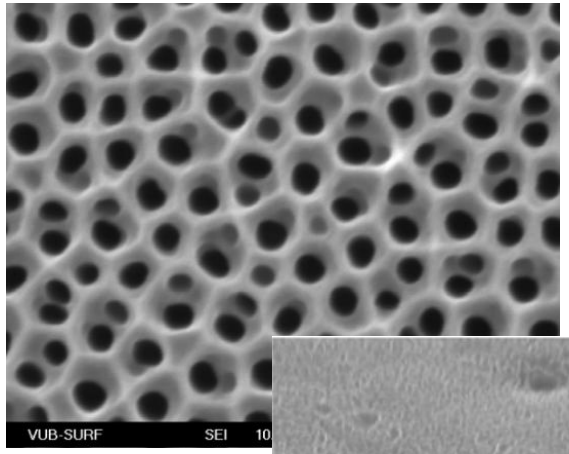

Energy storage

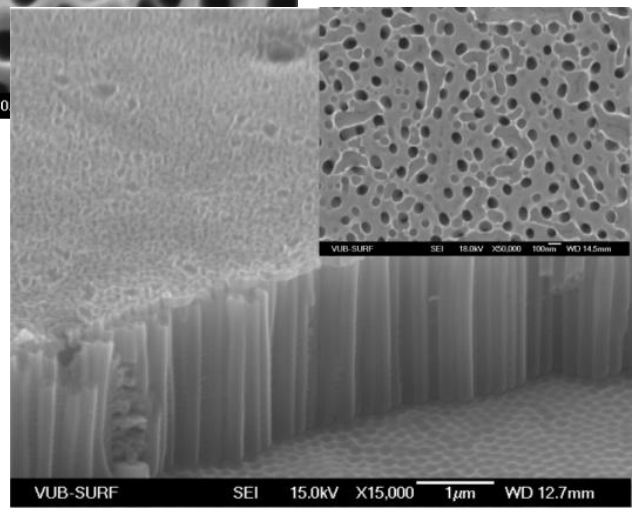

Energy convertion


Sensors

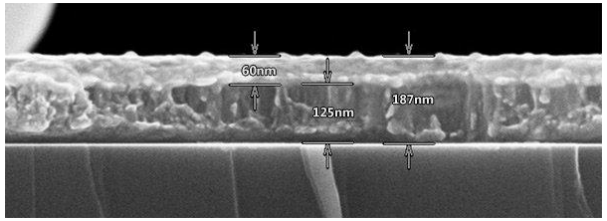
Synthesis of new functional nanomaterials

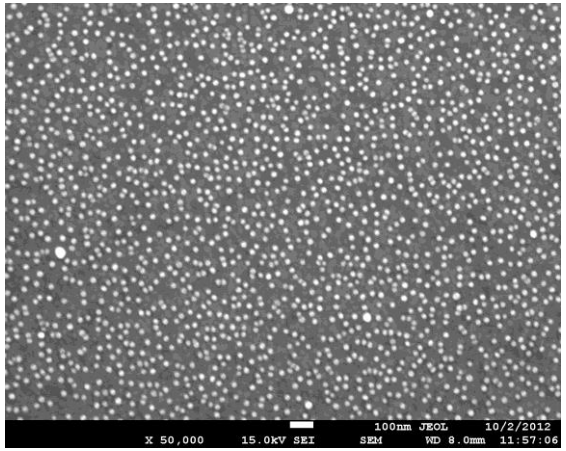
Nanoporous/nanotubular
Anodic metal oxides and semiconductors



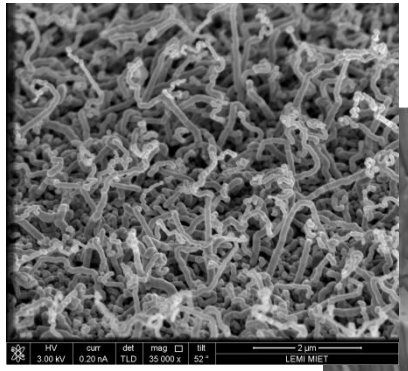


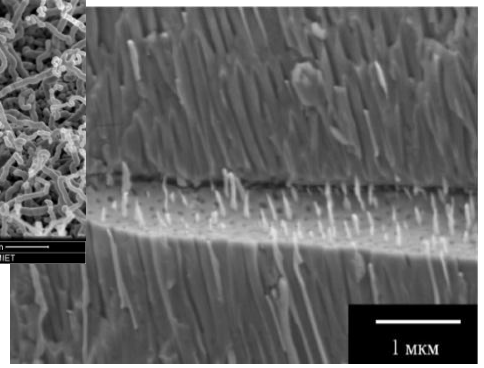
Thin films
and
nanoclusters

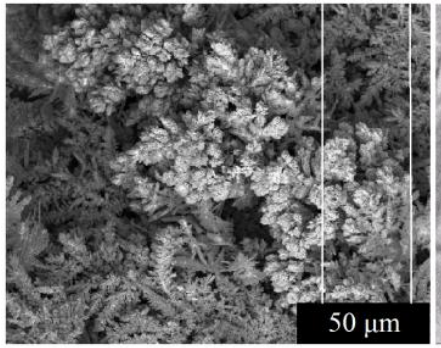


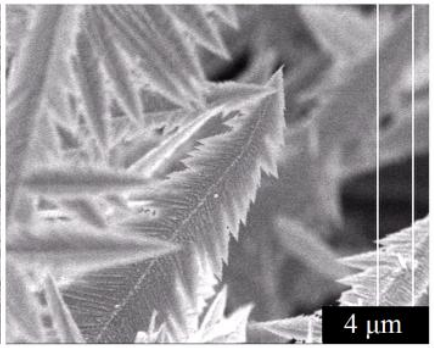


Nanorods, Nanowires,
Dendrites

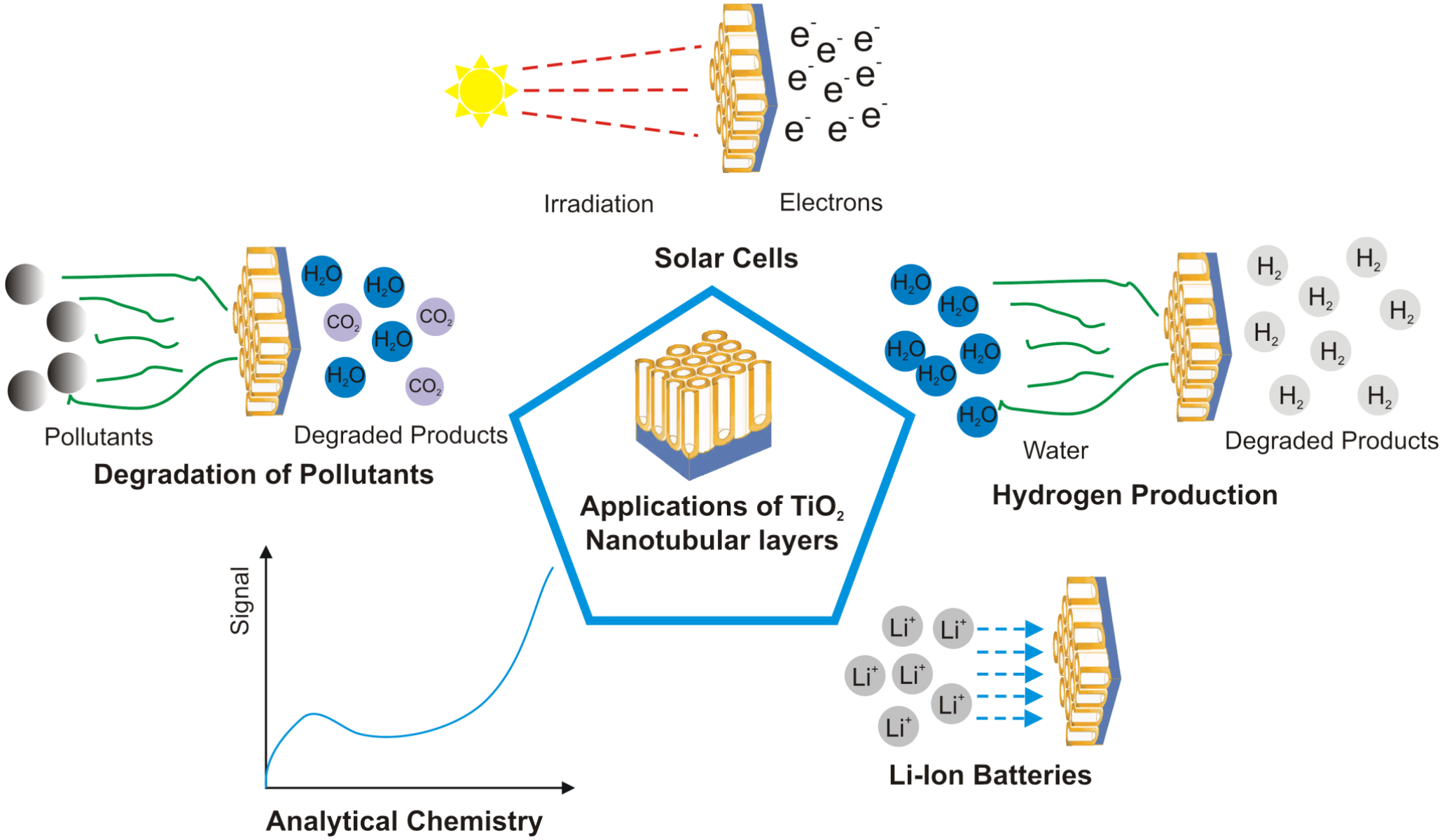




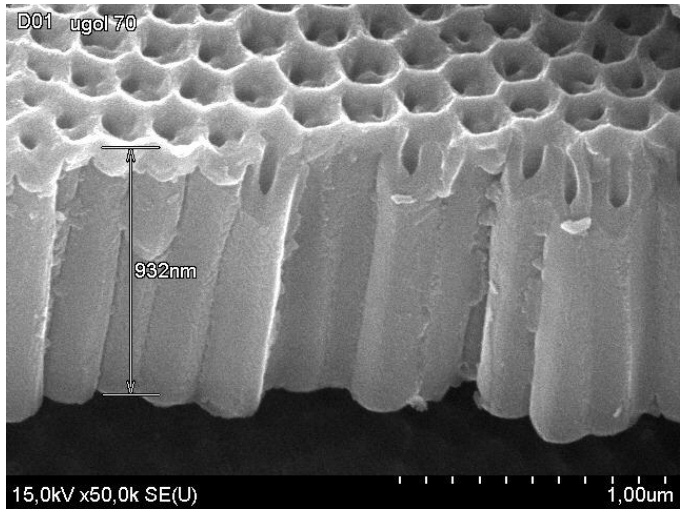




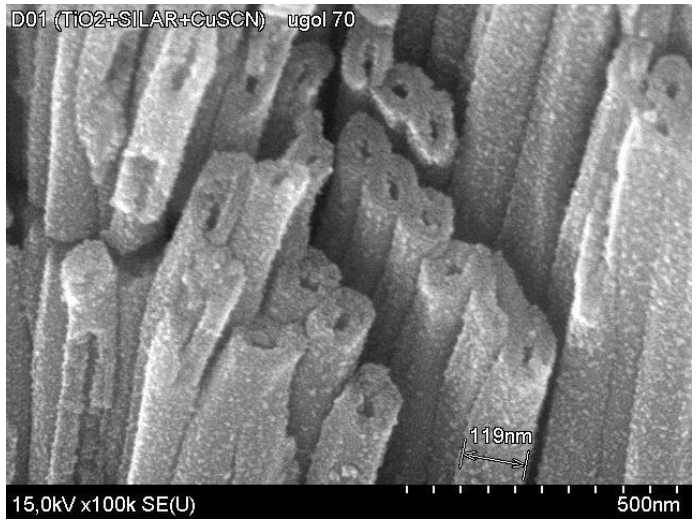
Applications of TiO_2 nanotubular layers



TiO_2 NTs for ETA solar cells

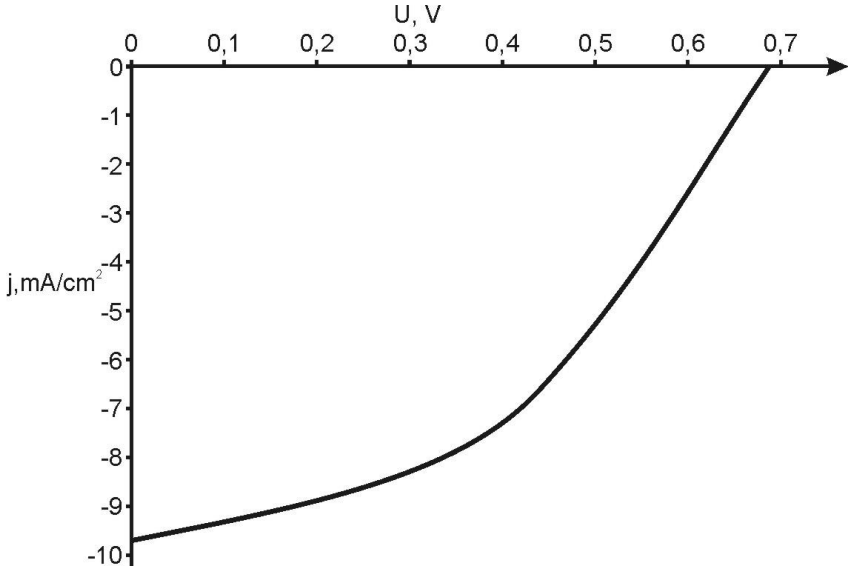


TiO_2 NTs on Ti foil



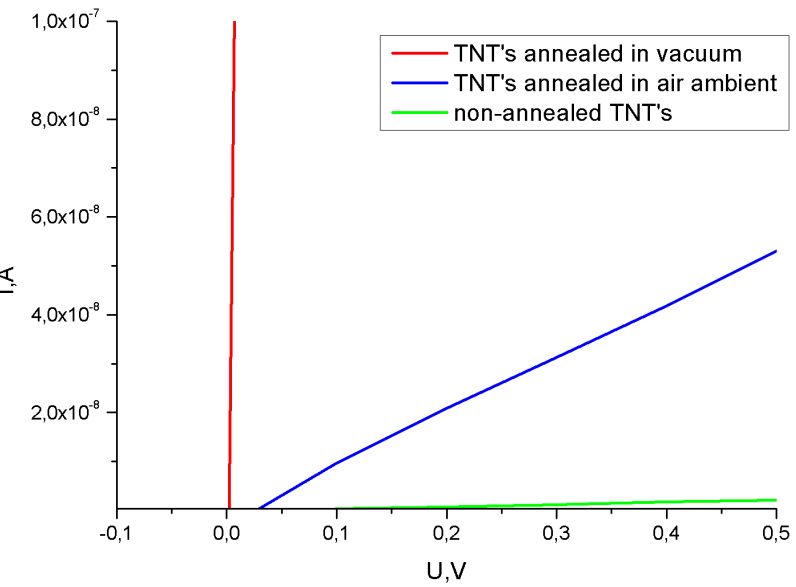
TiO_2 NTs after coating with thin light-adsorbing layer by SILAR method

Flexible ETA-cell

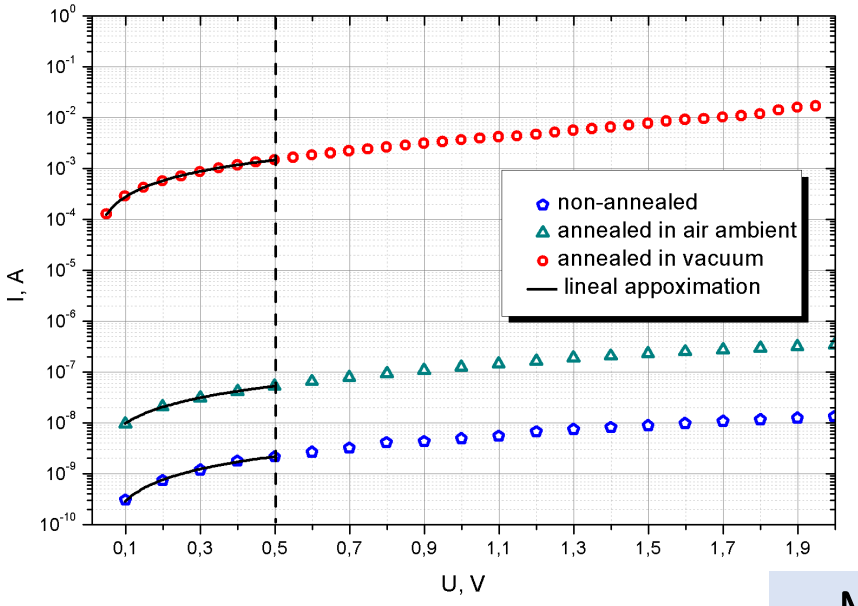


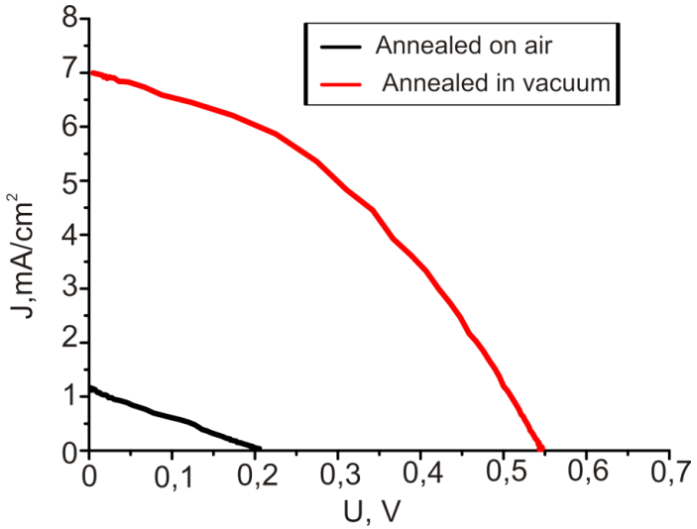
I-V curve of ETA-cell experimental sample

Modification of TiO_2 nanotubes for PC applications

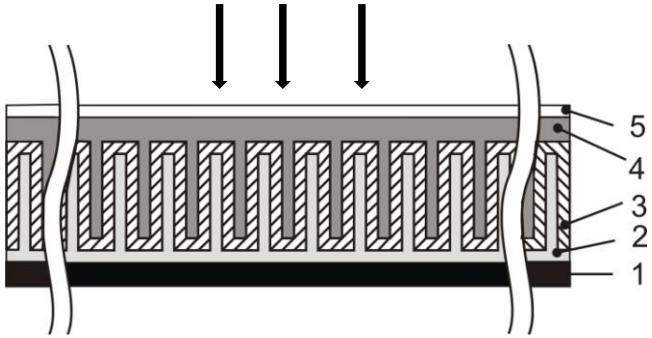


S_{cont}=0.01 mm^2





Light



1 - a flexible solid-state carrier and the bottom electrode layer 2 - layer of an electron acceptor made of nanostructured titanium dioxide, 3 - a functional layer which generate and the separate nonequilibrium charge carriers, 4 -holes acceptor layer, 5 - the top transparent electrode.

Main characteristics of obtained ETA-cells

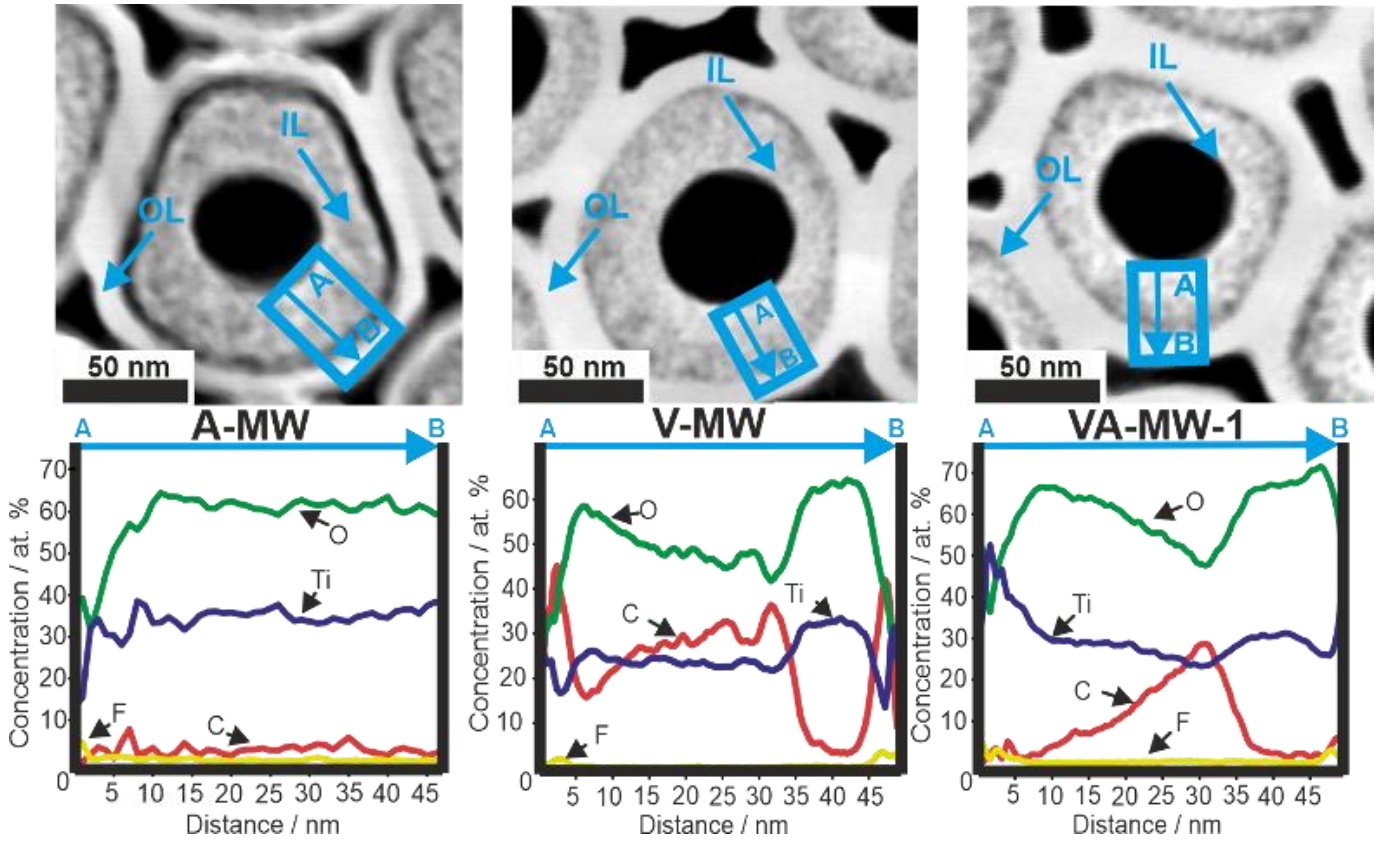
TNT layer modification	U_{oc}, V	J_{sc}, μA/cm²
Annealed in air ambient	0,211	116
Annealed in vacuum chamber	0,547	697

ETA-cell structure:

Ti foil/TiO_2 NTs/In_2S_3/$In_xPb_{1-x}S$/CuSCN/ITO

Gavrilin, I. M., Dronov, A. A., Shilyaeva, Y. I., Lebedev, E. A., Kuzmicheva, M. S., Savchuk, T. P., & Gavrilov, S. A. (2016). doi:10.1088/1742-6596/741/1/012100

TiO_2 NTs morphology and composition



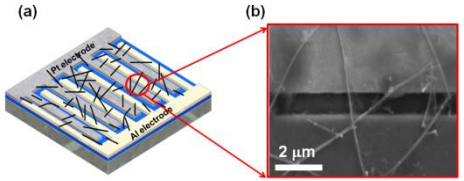
Thermal treatment:
450 °C for 1 hour
in air

Thermal treatment:
450 °C for 1 hour
in vacuum

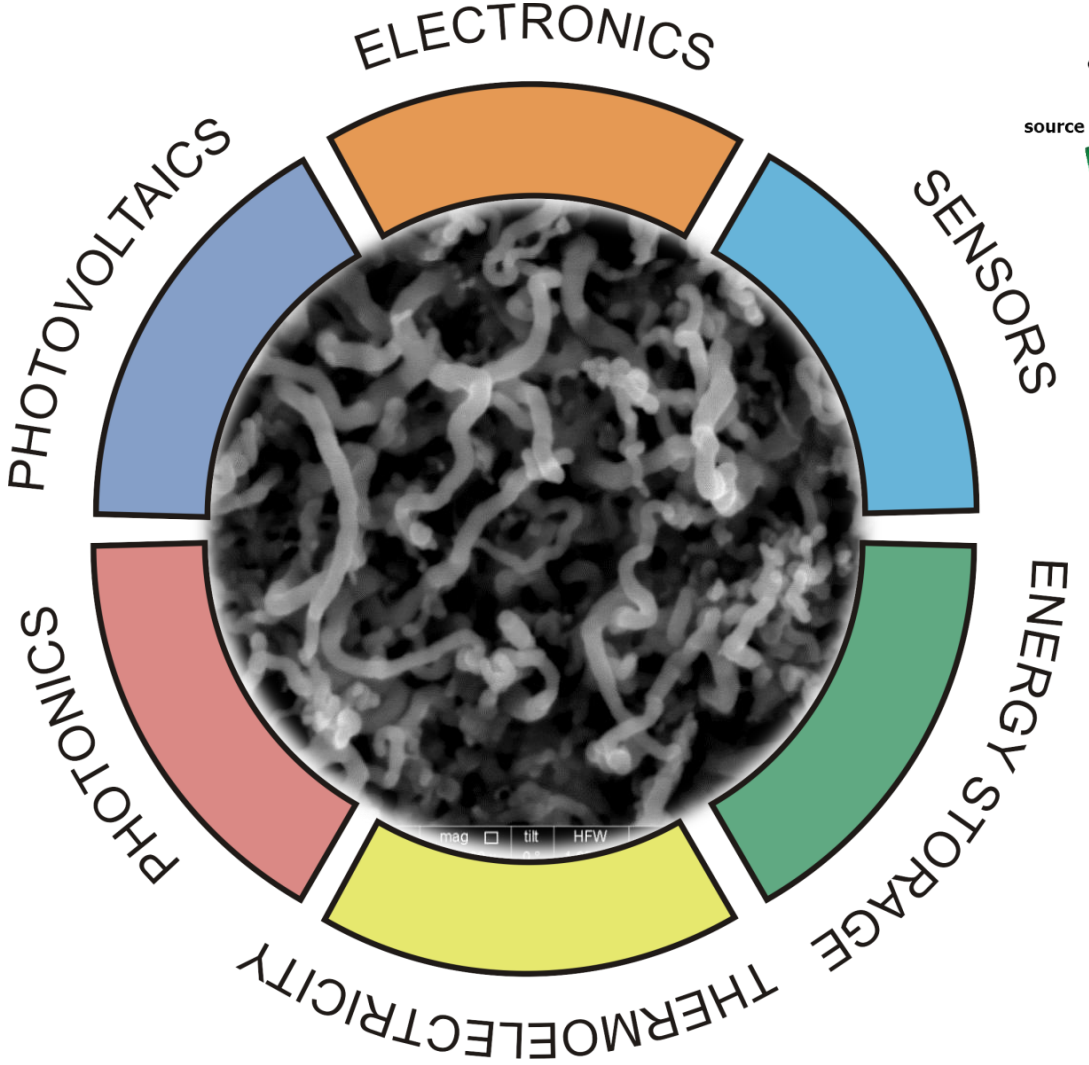
Thermal treatment:
450 °C for 1 hour
in vacuum
300 °C for 1 hour
in air

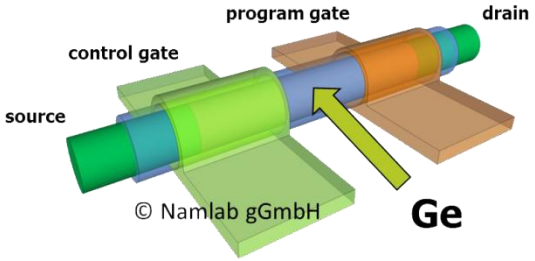
I. Gavrilin, A. Dronov, R. Volkov, T. Savchuk, D. Dronova, N. Borgardt, A. Pavlikov, S. Gavrilov, and D. Gromov (2020). doi:10.1016/j.apsusc.2020.146120

Ge nanowires perspective applications

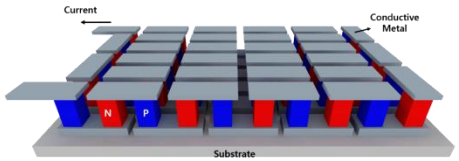


Yun et al. Nanoscale Research Letters 2011, 6:287

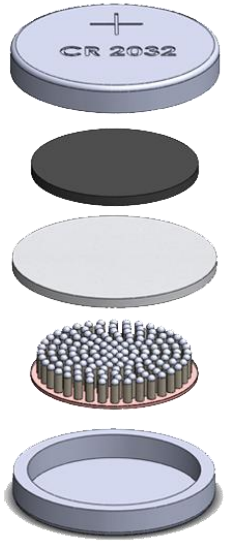




Trommer, J. et al., 2017. ACS Nano, 11(2), pp.1704–1711.

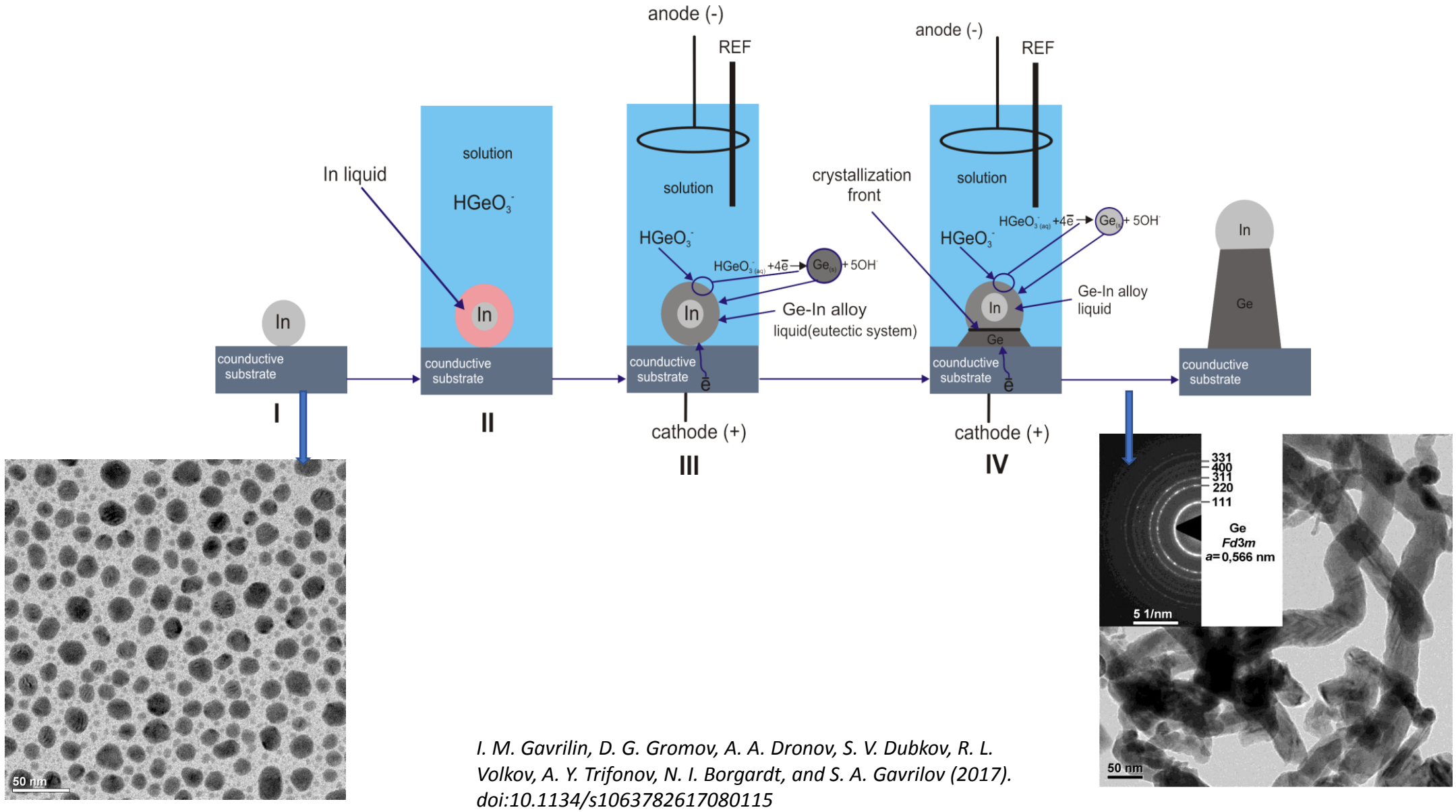


Youcef Banouni, 2010



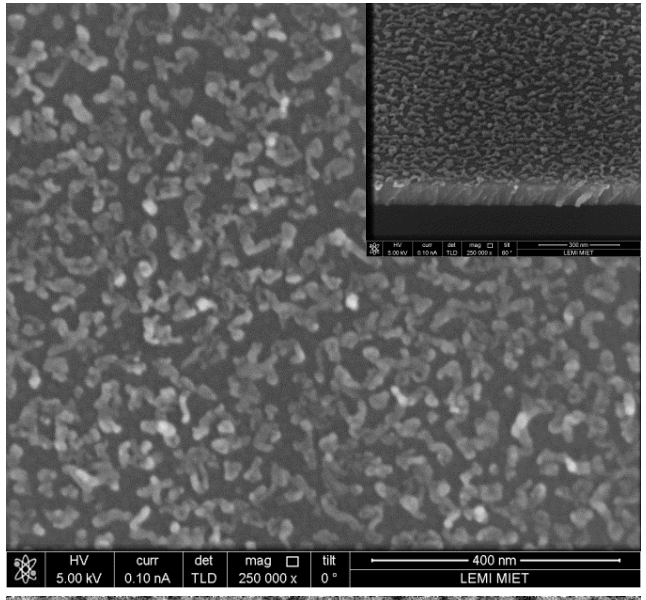
Ma, L. et al., 2016. ACS Energy Letters, 2(1), pp.238–243.

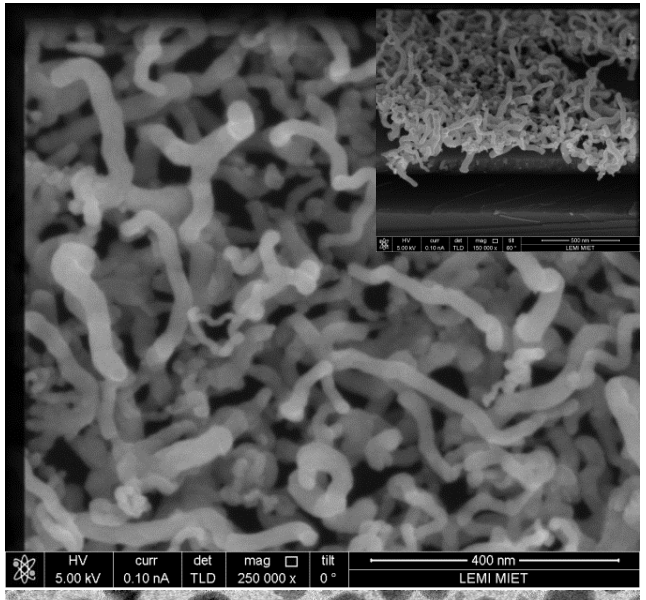
Germanium nanowires growth by ec-LLS

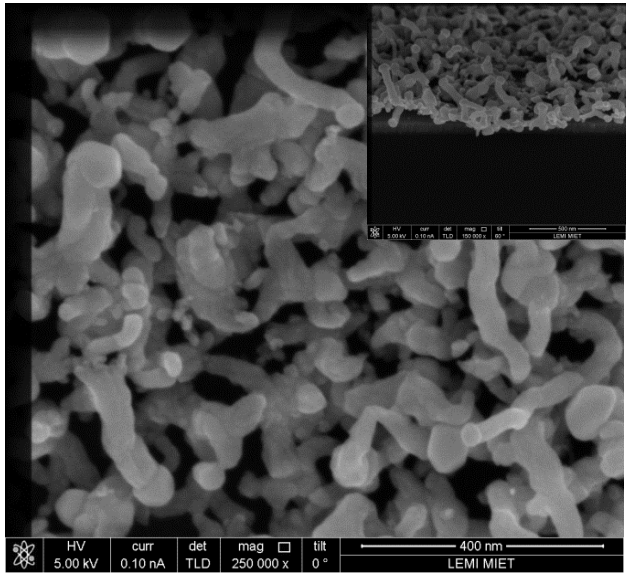


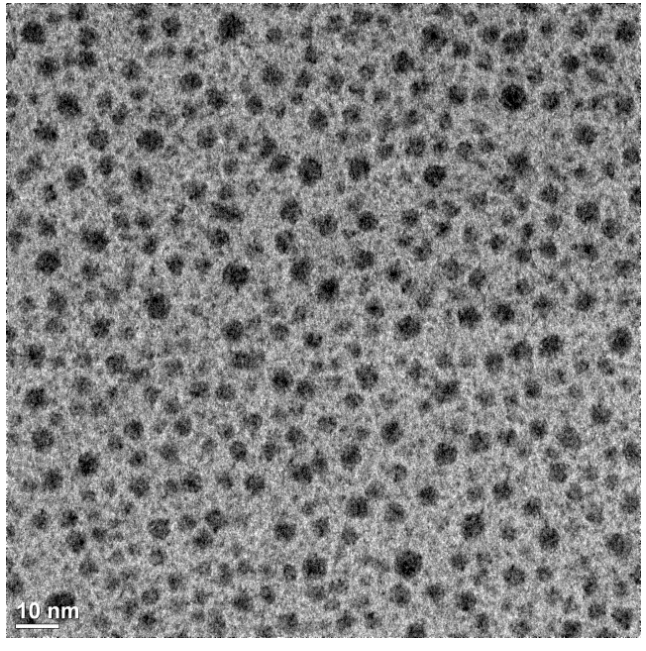
I. M. Gavrilin, D. G. Gromov, A. A. Dronov, S. V. Dubkov, R. L. Volkov, A. Y. Trifonov, N. I. Borgardt, and S. A. Gavrilov (2017). doi:10.1134/s1063782617080115

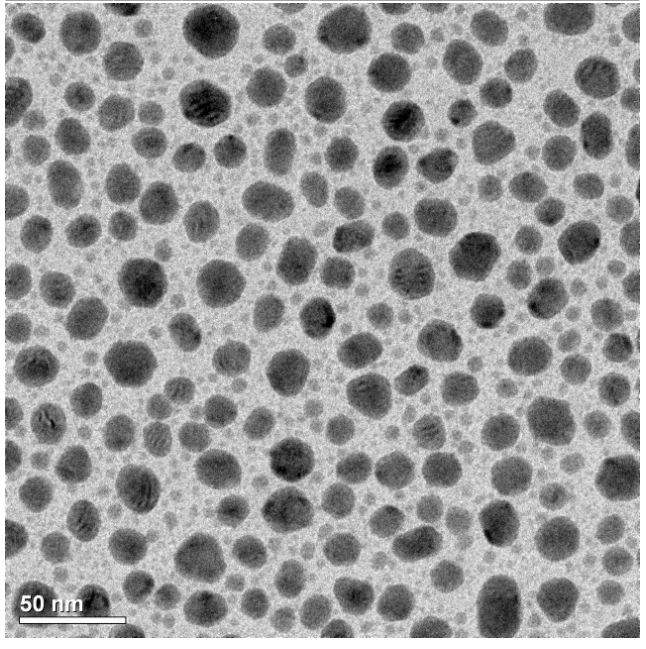
Ge nanowires morphology on size of In nanodroplets

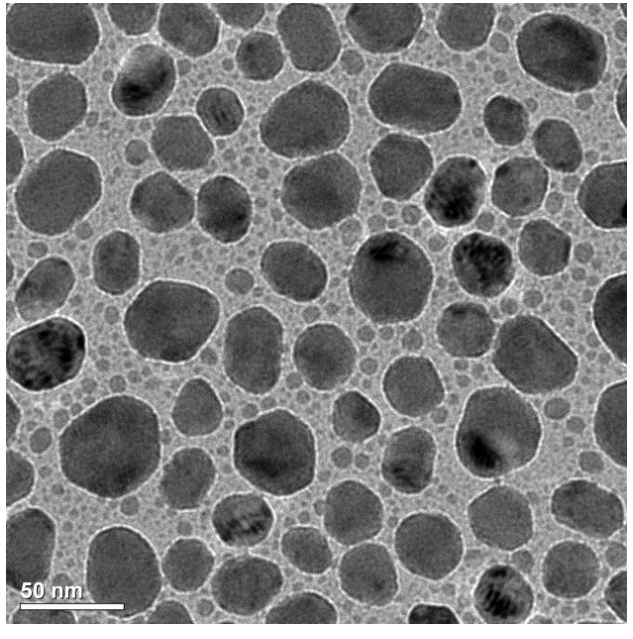




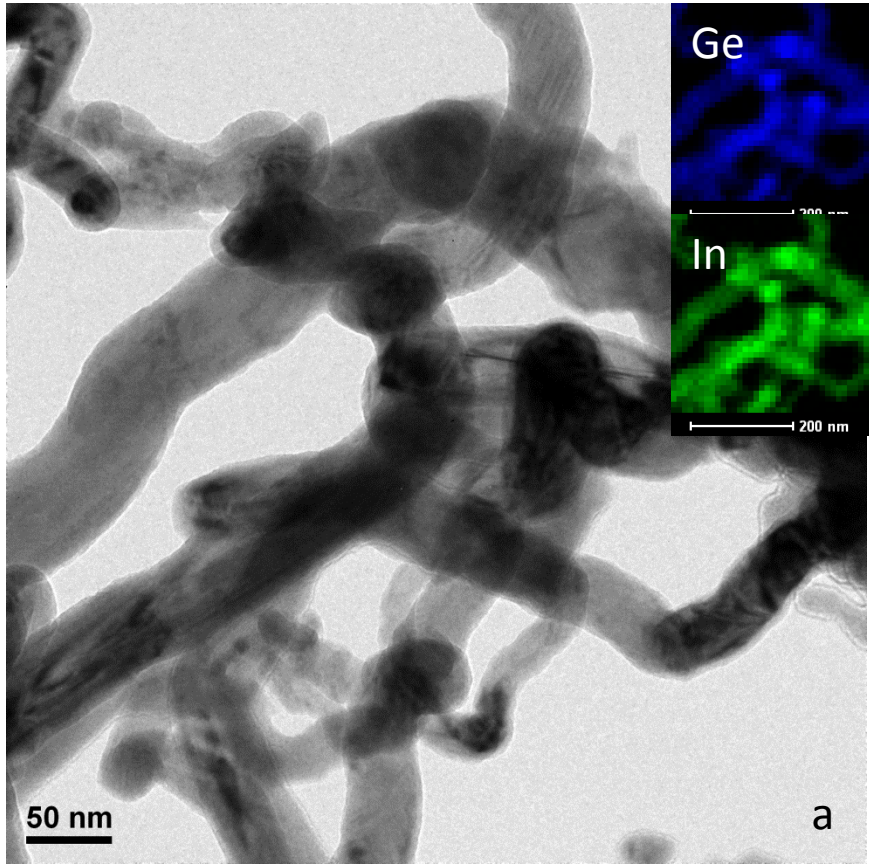


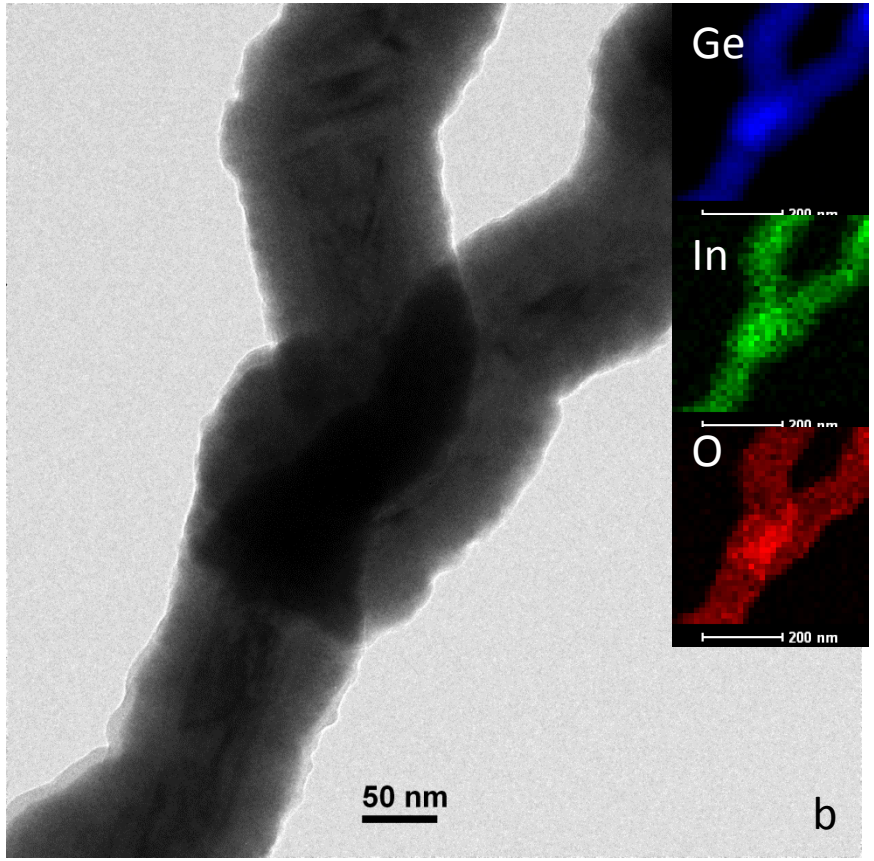






TEM investigations of obtained GeNW structures

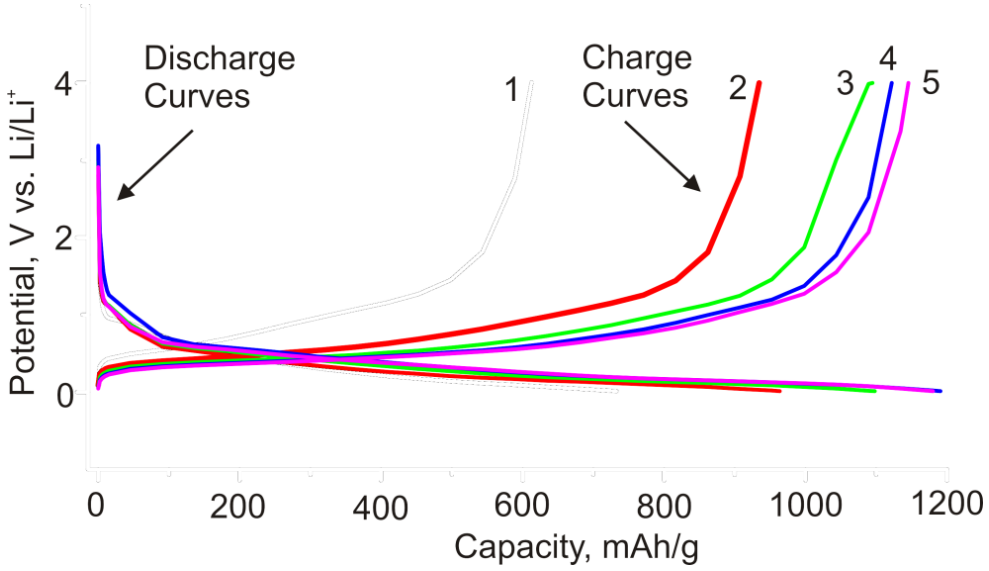




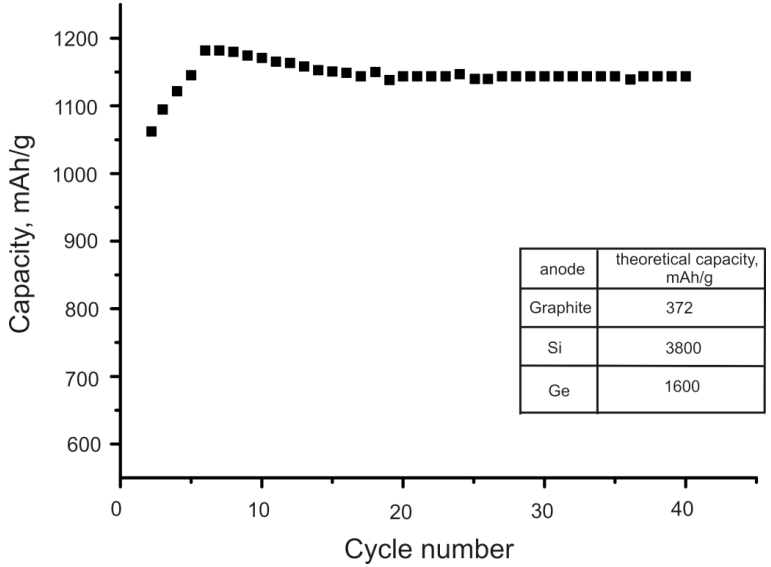
TEM images and Elemental Mappings of GeNWs formed on In nanoparticles at different solution temperature: a- 60°C and b – 90°C.

The solubility of In atoms in Ge is ~ **10^{-2} atom.%**

GeNW anode for Li-ion batteries



Charge-discharge curves of GeNW anode. $J_{discharge}$ = 0,5 mA.` S = 2.5 cm^2. Electrolyte 1 M $LiPF_6$ in a mixture of EC-DEC-DMC (1:1:1). Weight: 0.55 mg.

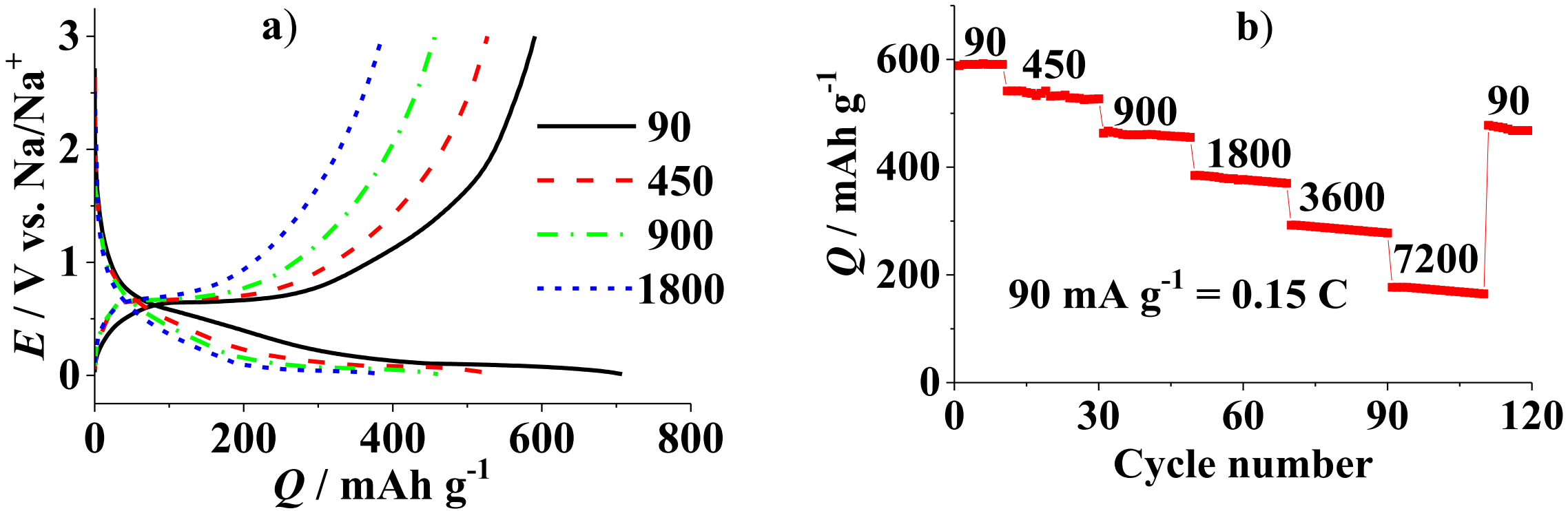


anode	theoretical capacity, mAh/g
Graphite	372
Si	3800
Ge	1600

Change in the discharge capacity of the GeNW electrode. S = 2.1 cm^2. Electrolyte 1 M $LiPF_6$ in a mixture of EC-DEC-DMC (1:1:1). Weight: 0.55 mg.

I. M. Gavrilin, V. A. Smolyaninov, A. A. Dronov, S. A. Gavrilov, A. Y. Trifonov, T. L. Kulova, A. A. Kuz'mina, and A. M. Skundin (2018). doi:10.1134/s1023193518120054

GeNW anode for Na-ion batteries



Charge-discharge curves (a) and change in the reversible capacity (b) of the germanium-based electrode at the insertion-extraction of sodium at different current densities.

I. M. Gavrilin, V. A. Smolyaninov, A. A. Dronov, S. A. Gavrilov, A. Y. Trifonov, T. L. Kulova, A. A. Kuz'mina, and A. M. Skundin (2018). doi:10.1016/j.mencom.2018.11.034

Thanks for your kind attention!