

ФРУМКИНСКИЕ ЧТЕНИЯ

24 октября 2017

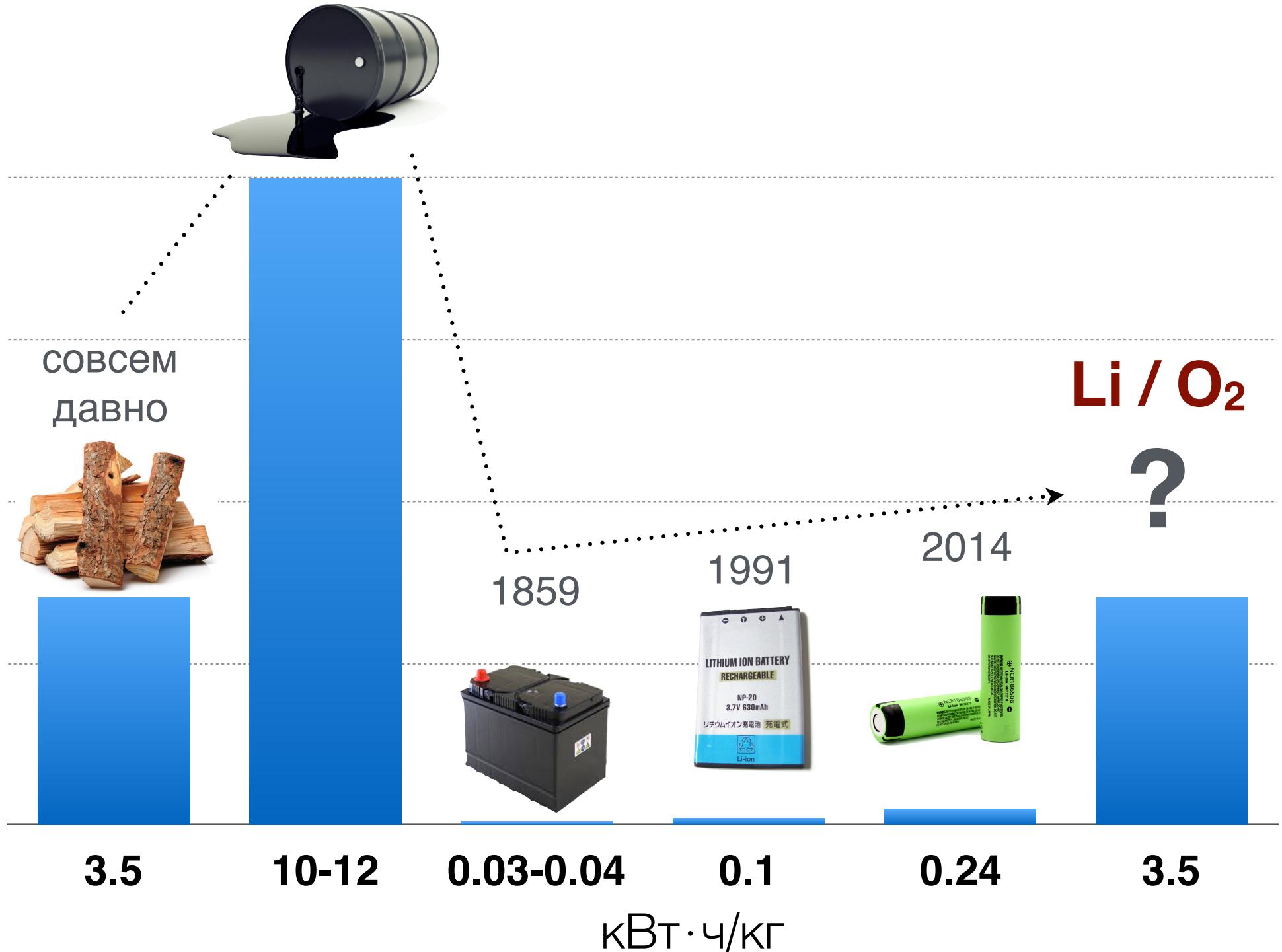
(Не)стабильность углеродных
электродов
в литий-кислородных аккумуляторах

Алина Белова



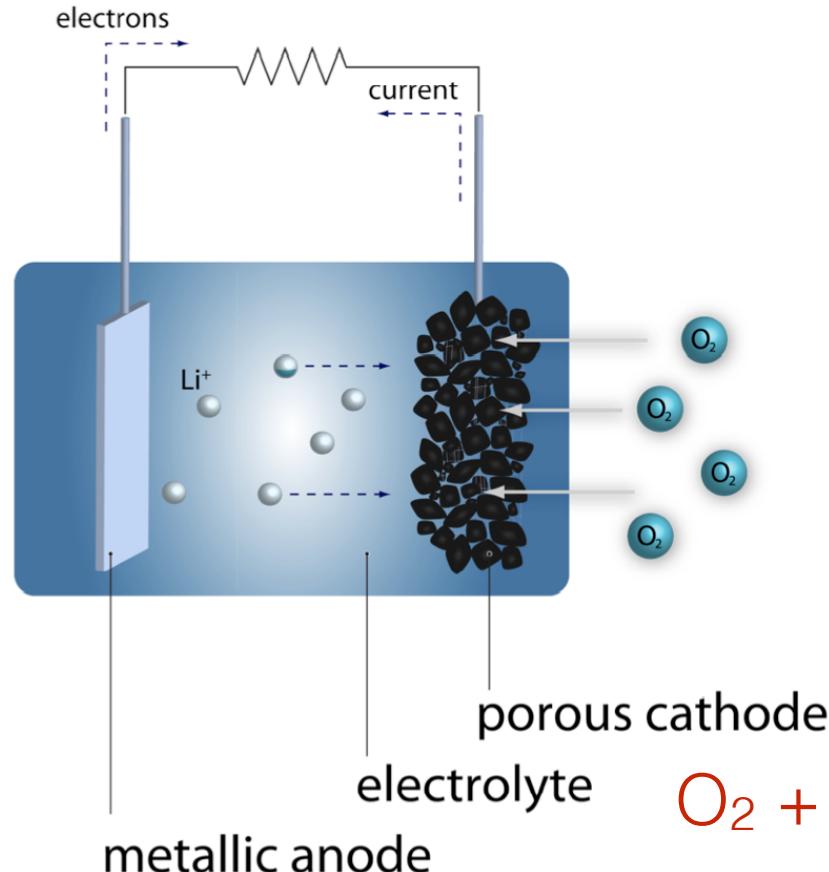
Факультет наук о материалах
МГУ имени М.В.Ломоносова

XVIII век



Литий-кислородный ХИТ

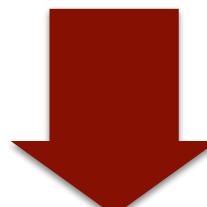
теоретическое напряжение
2.96 V



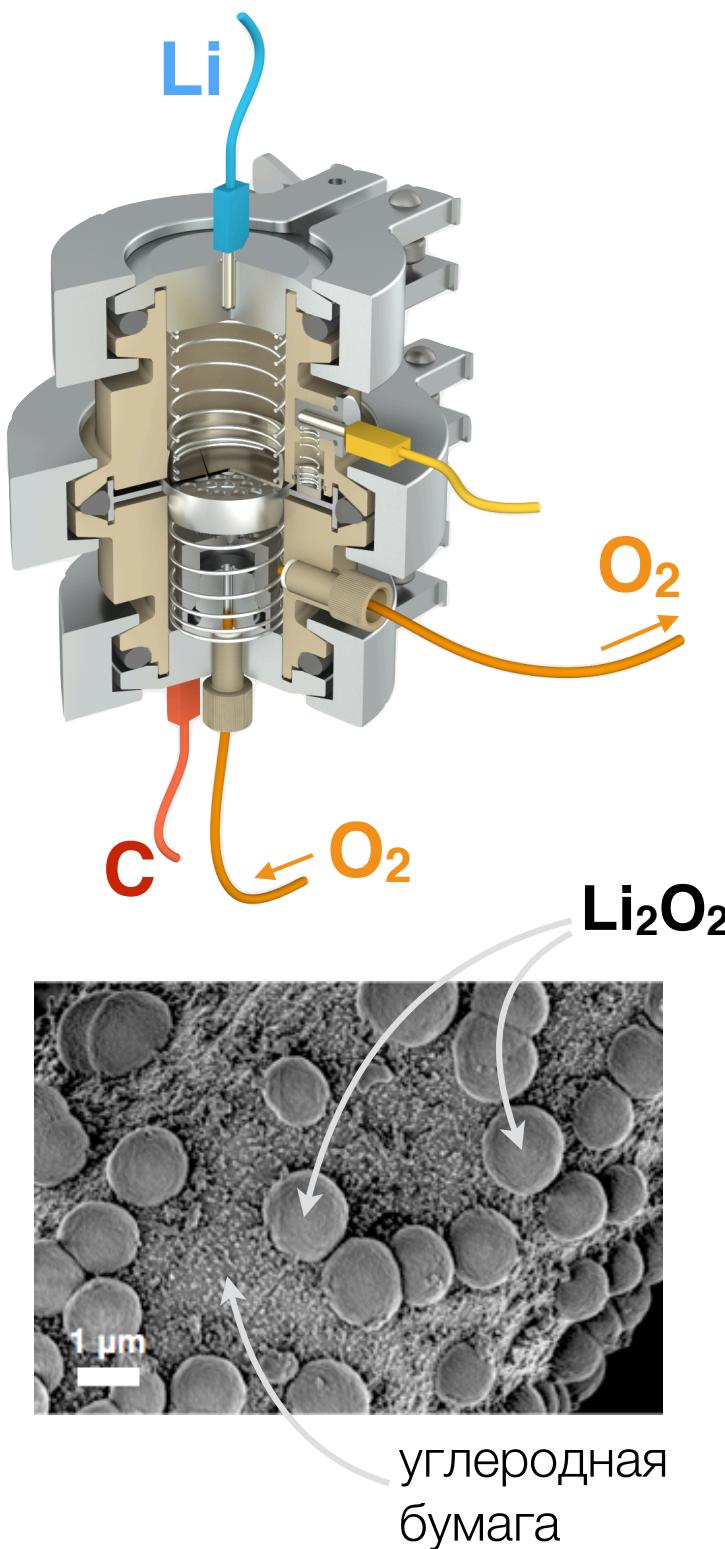
Апротонные электролиты:
 CH_3CN , DMSO , сульфоны, эфиры,
ионные жидкости...

Требования для положительного электрода:

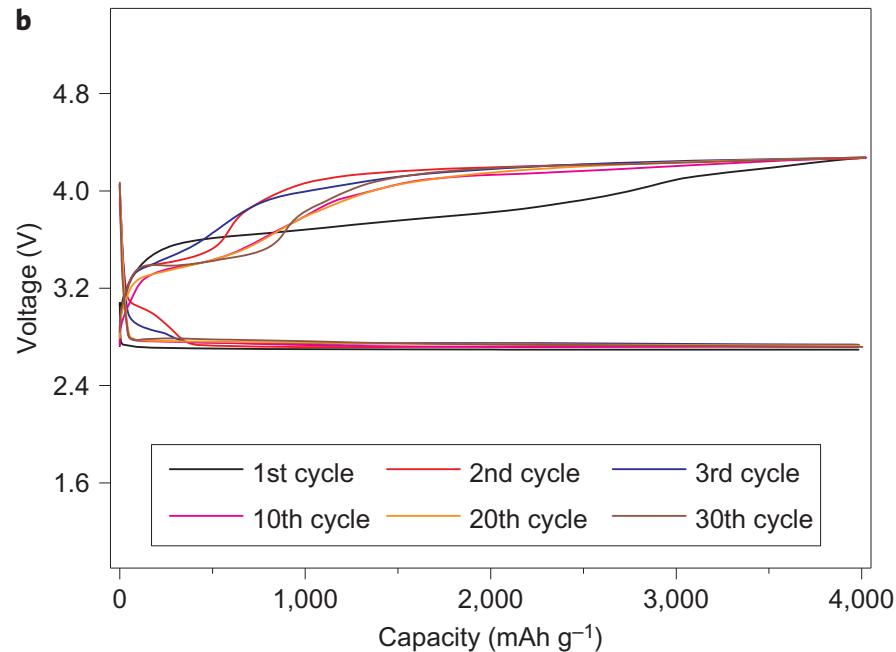
- низкий удельный вес
- высокая электронная проводимость
- высокая пористость
- (Электро)химическая стабильность



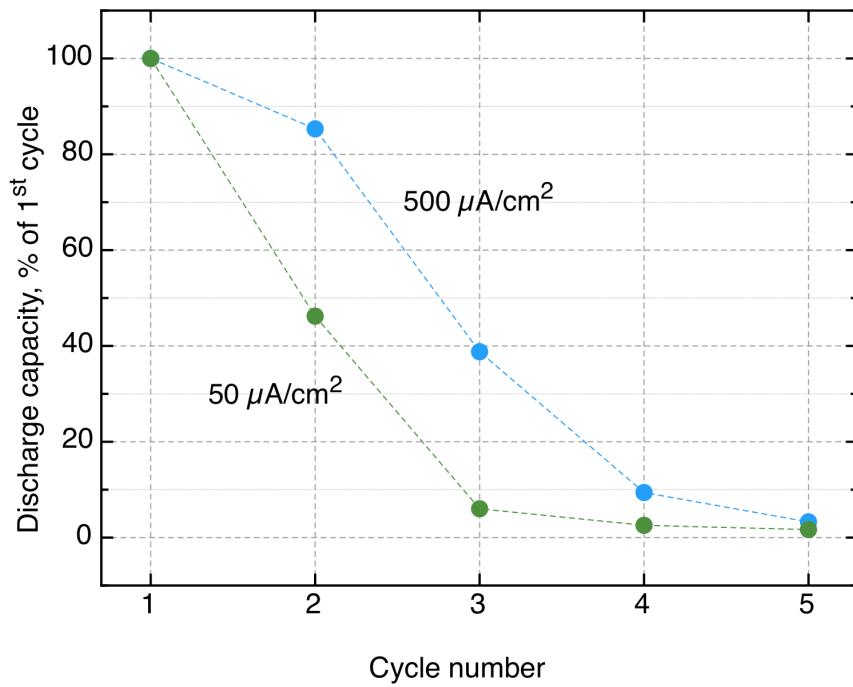
углерод?

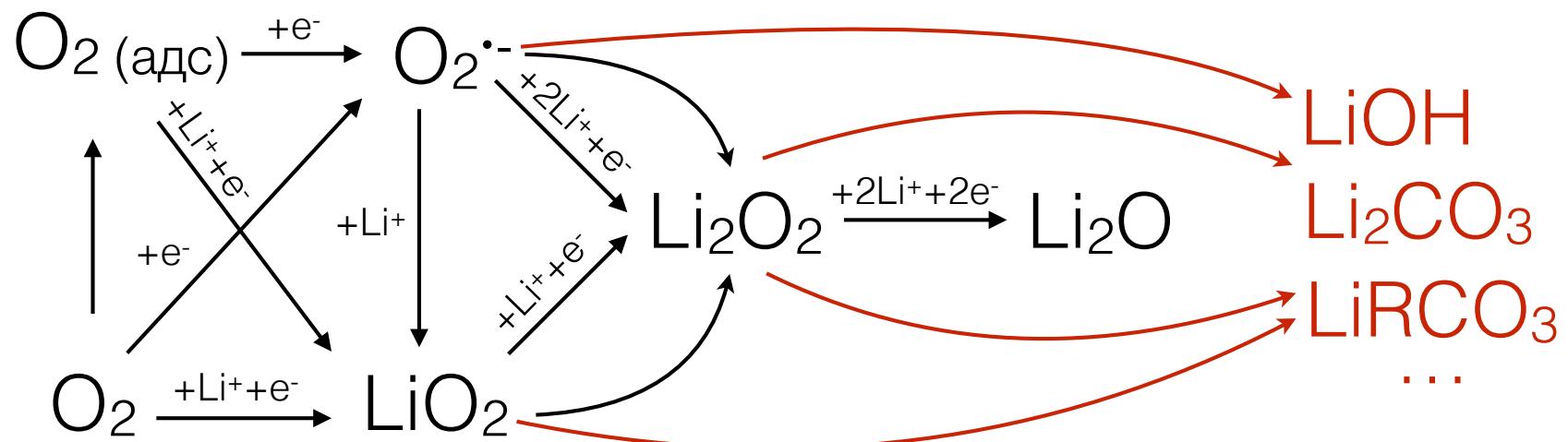
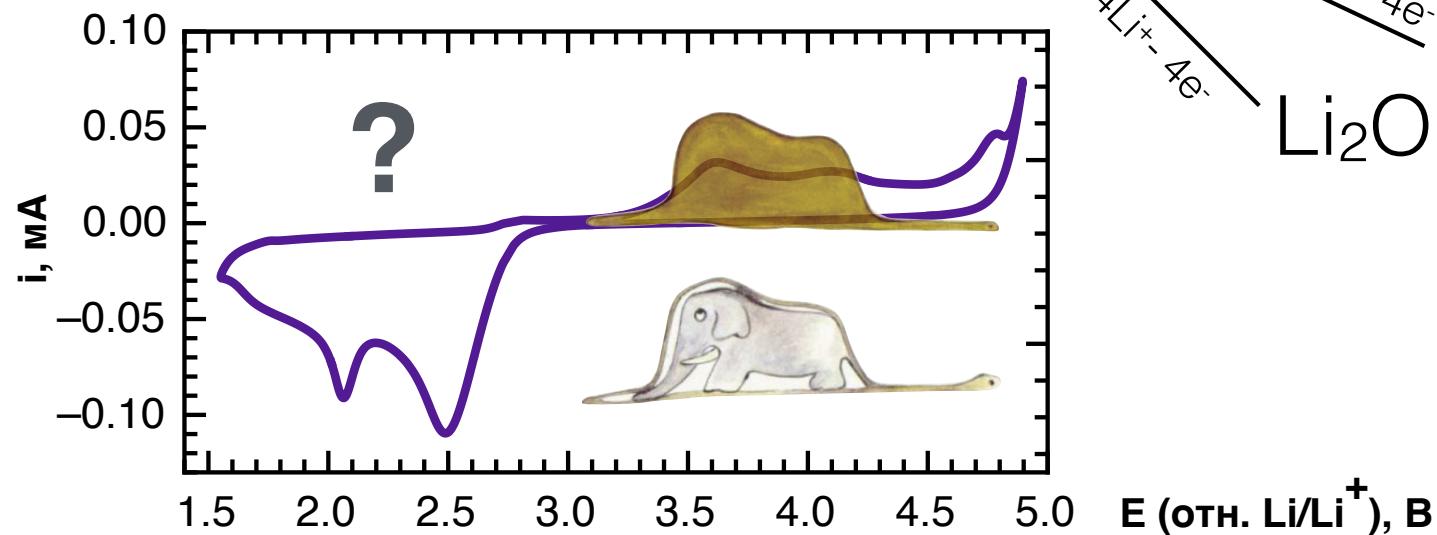
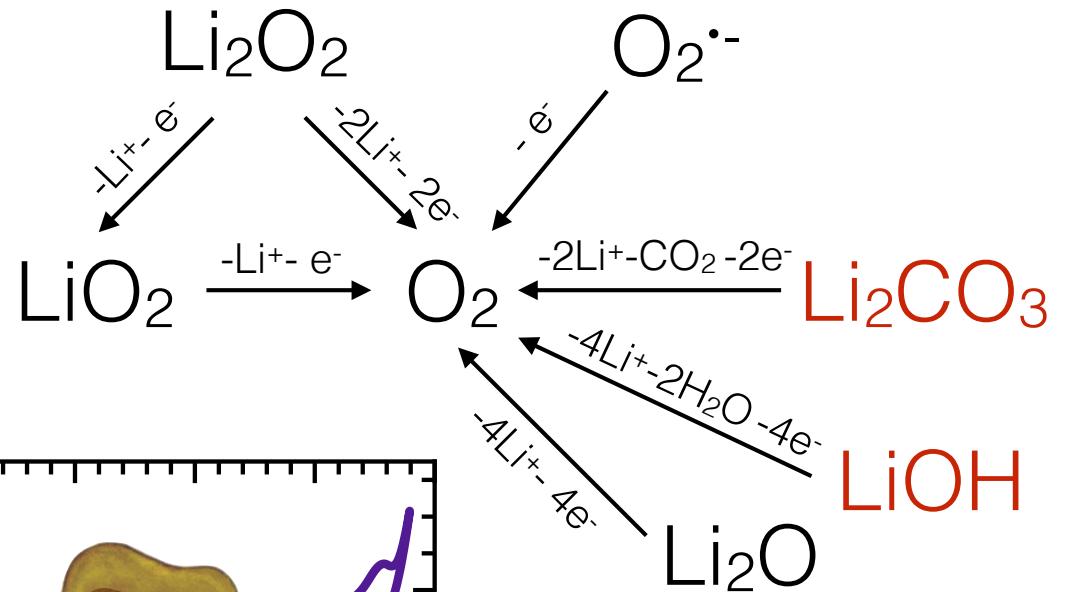
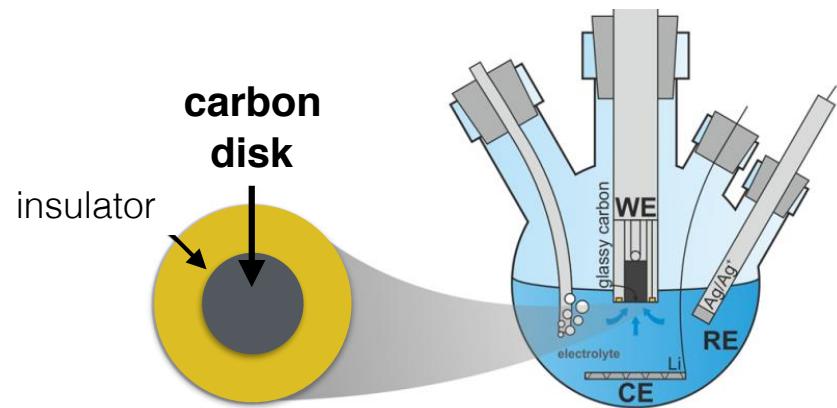


глубокий разряд

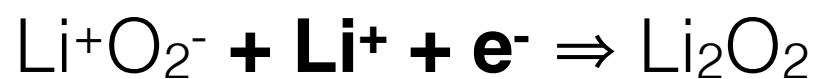
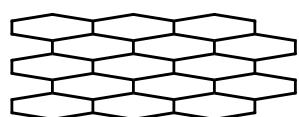
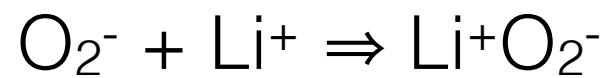
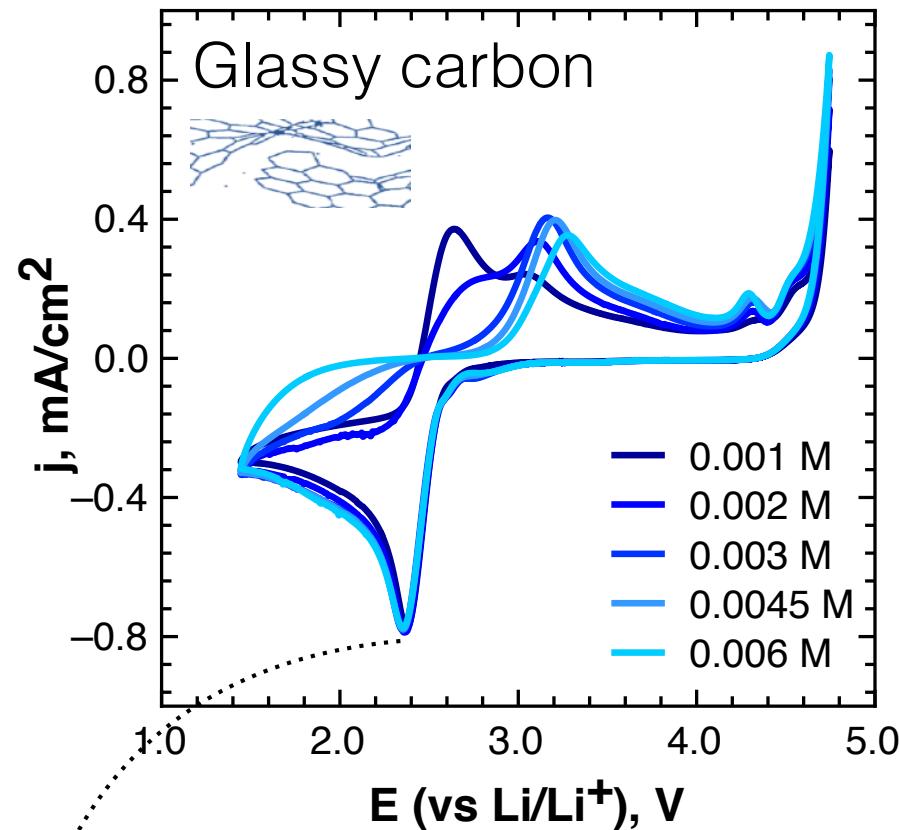
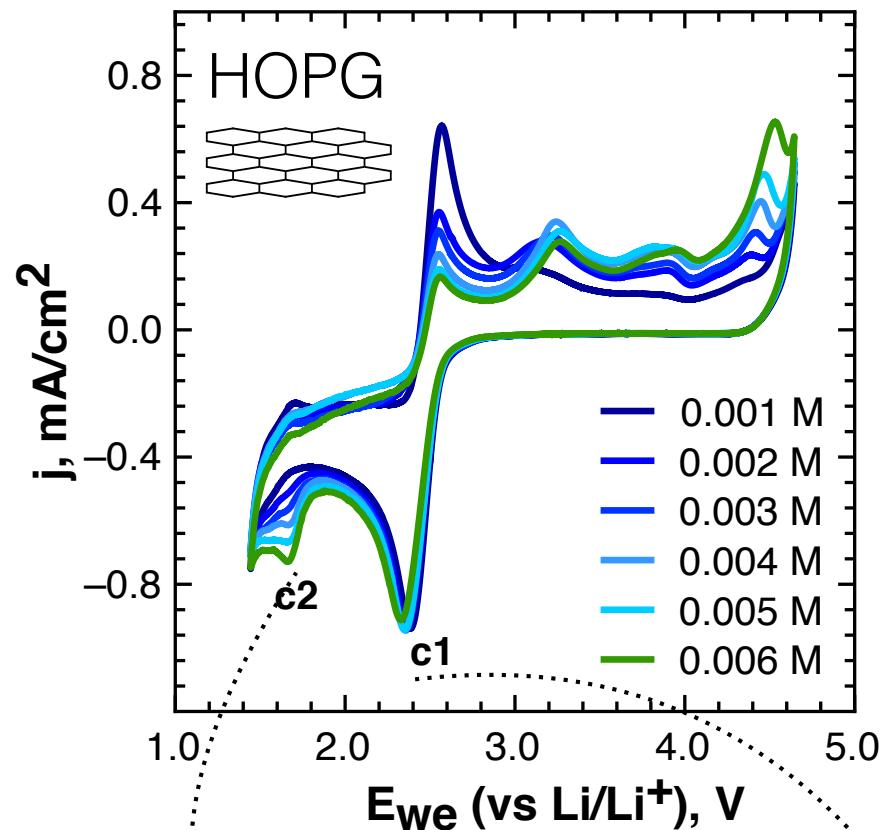


H.G.Jung et al. // Nat. Chem. 4 (2012)

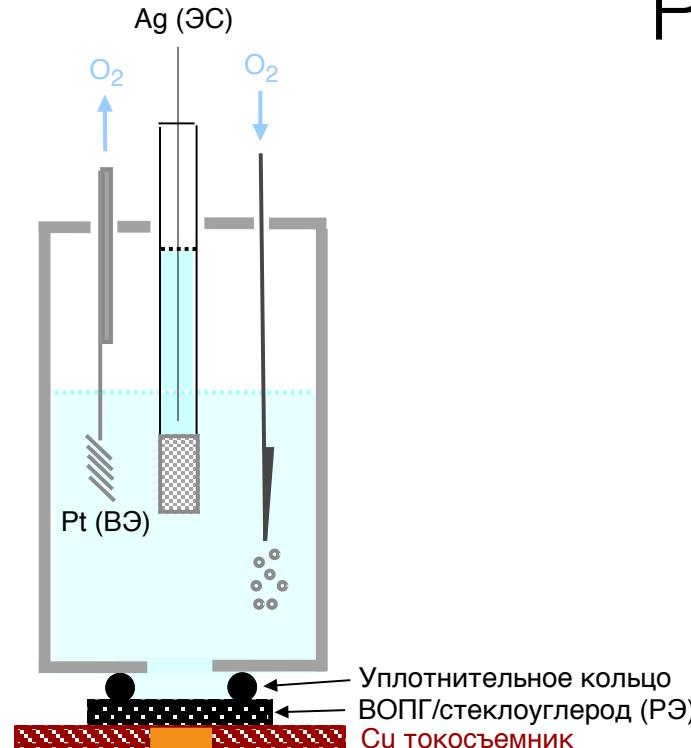




TBACIO₄ + x LiClO₄ in DMSO

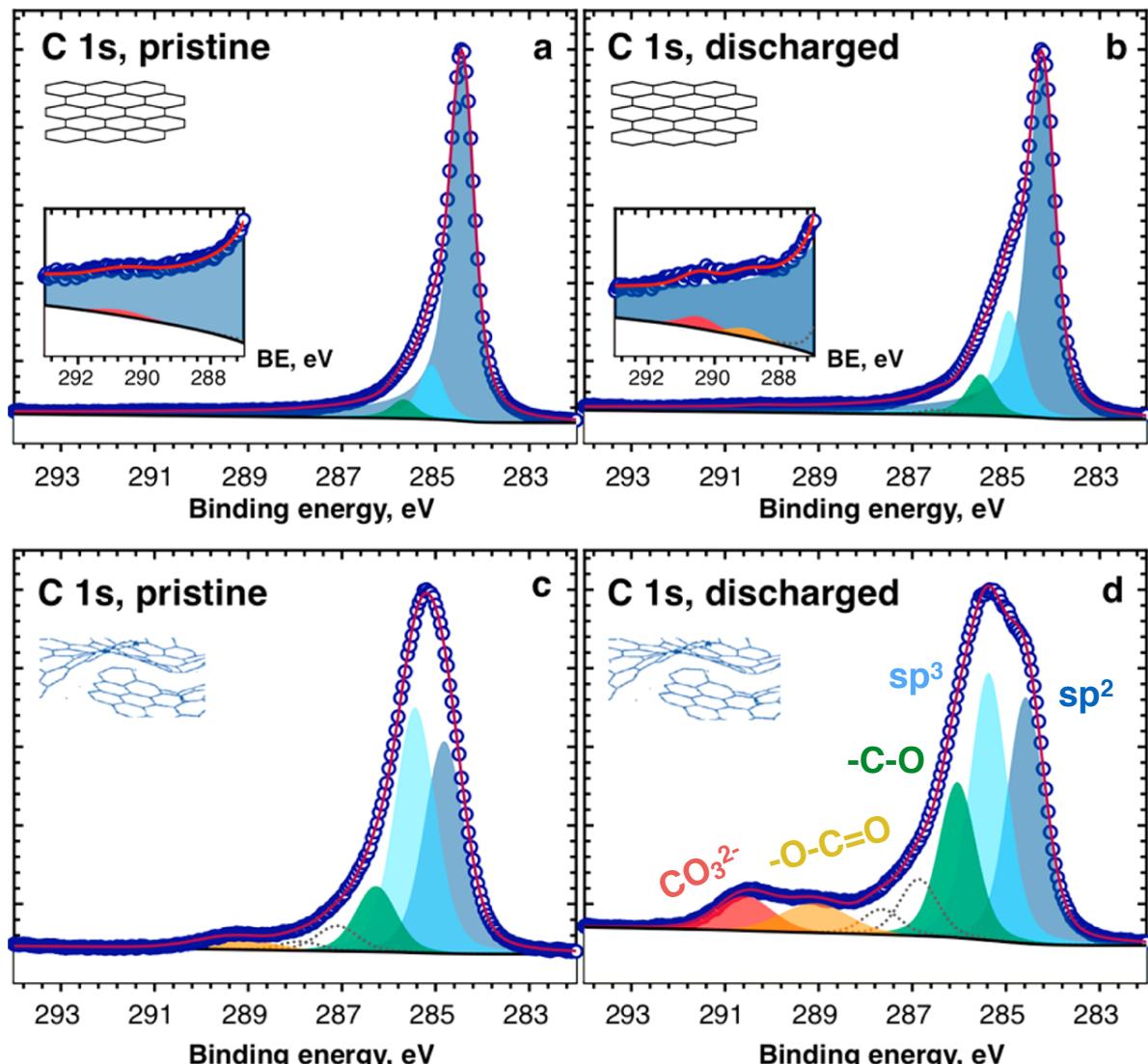


Рентгеновская фотоэлектронная спектроскопия (XPS) *ex situ*

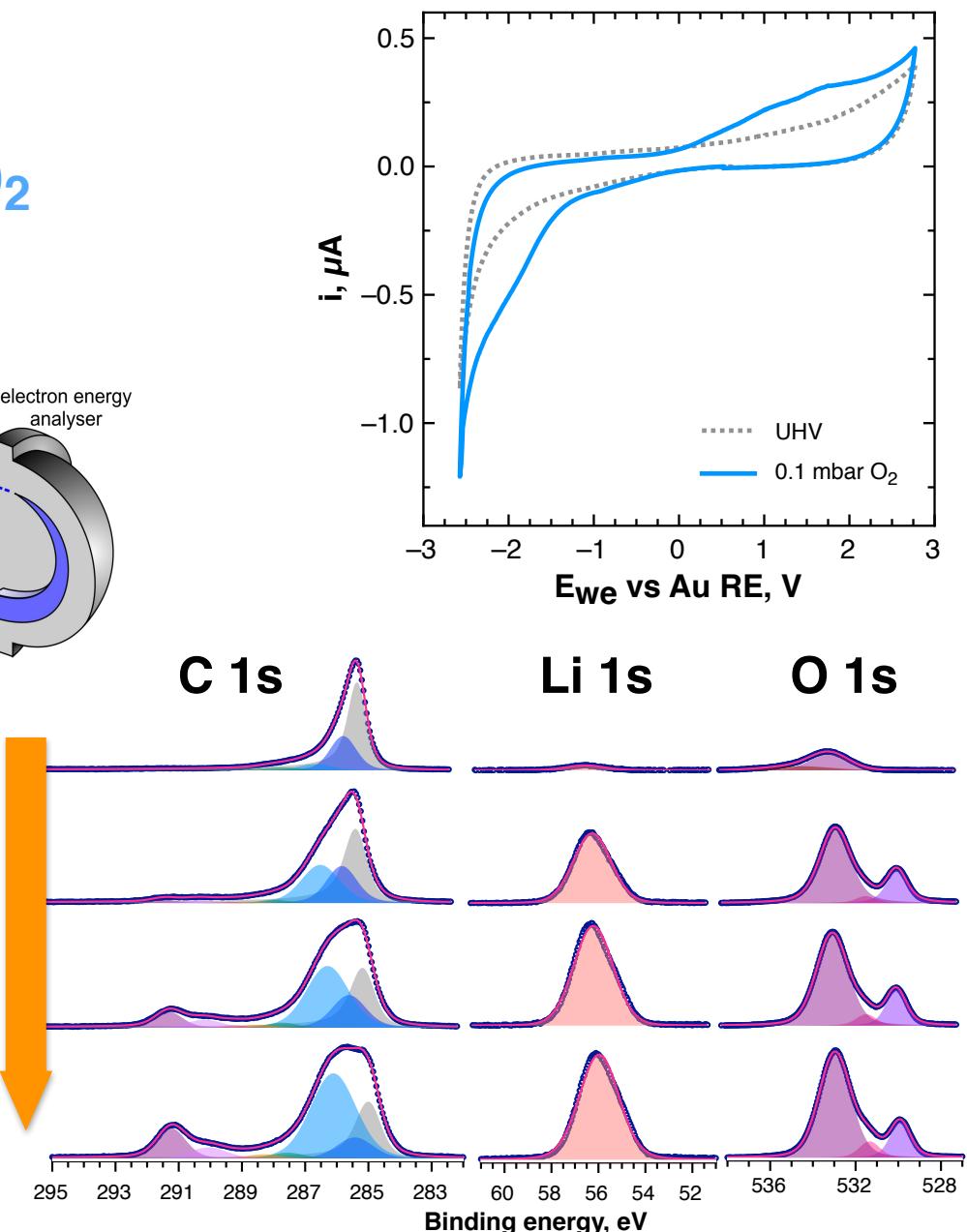
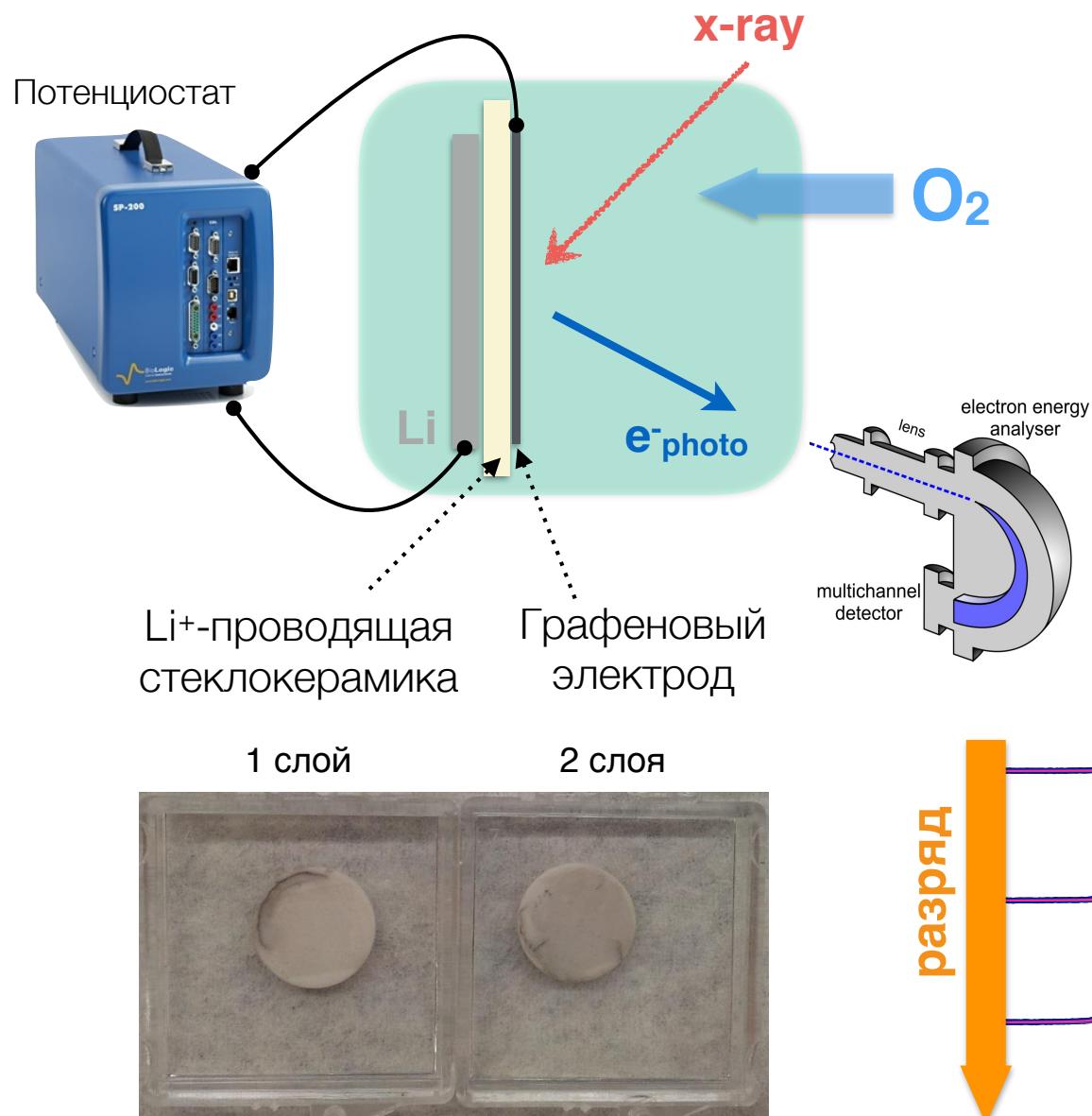


Уравнение Эйнштейна

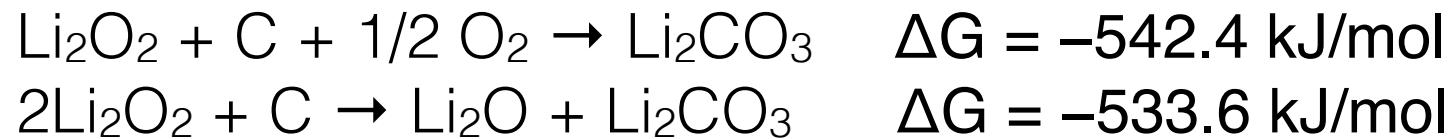
$$E_{\text{kin}} = h\nu - E_{\text{bin}}$$



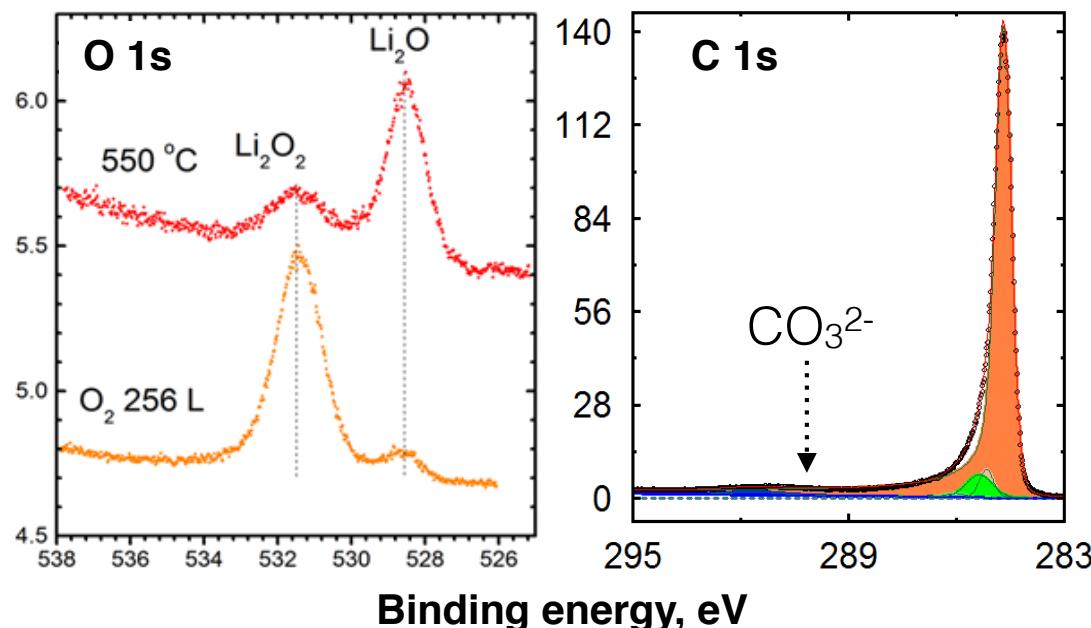
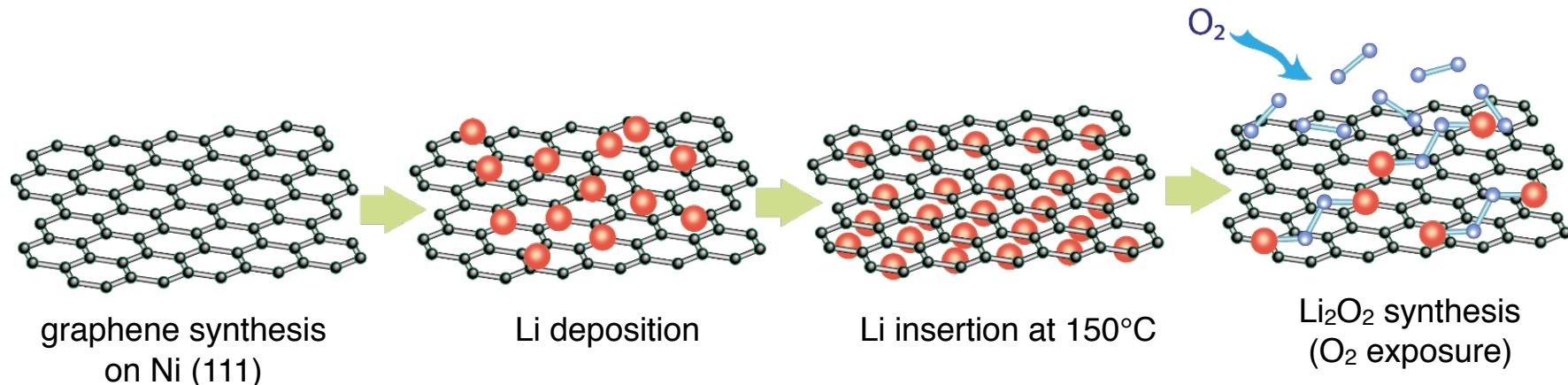
Рентгеновская фотоэлектронная спектроскопия (XPS) *in situ*



В чем причина деградации углерода?



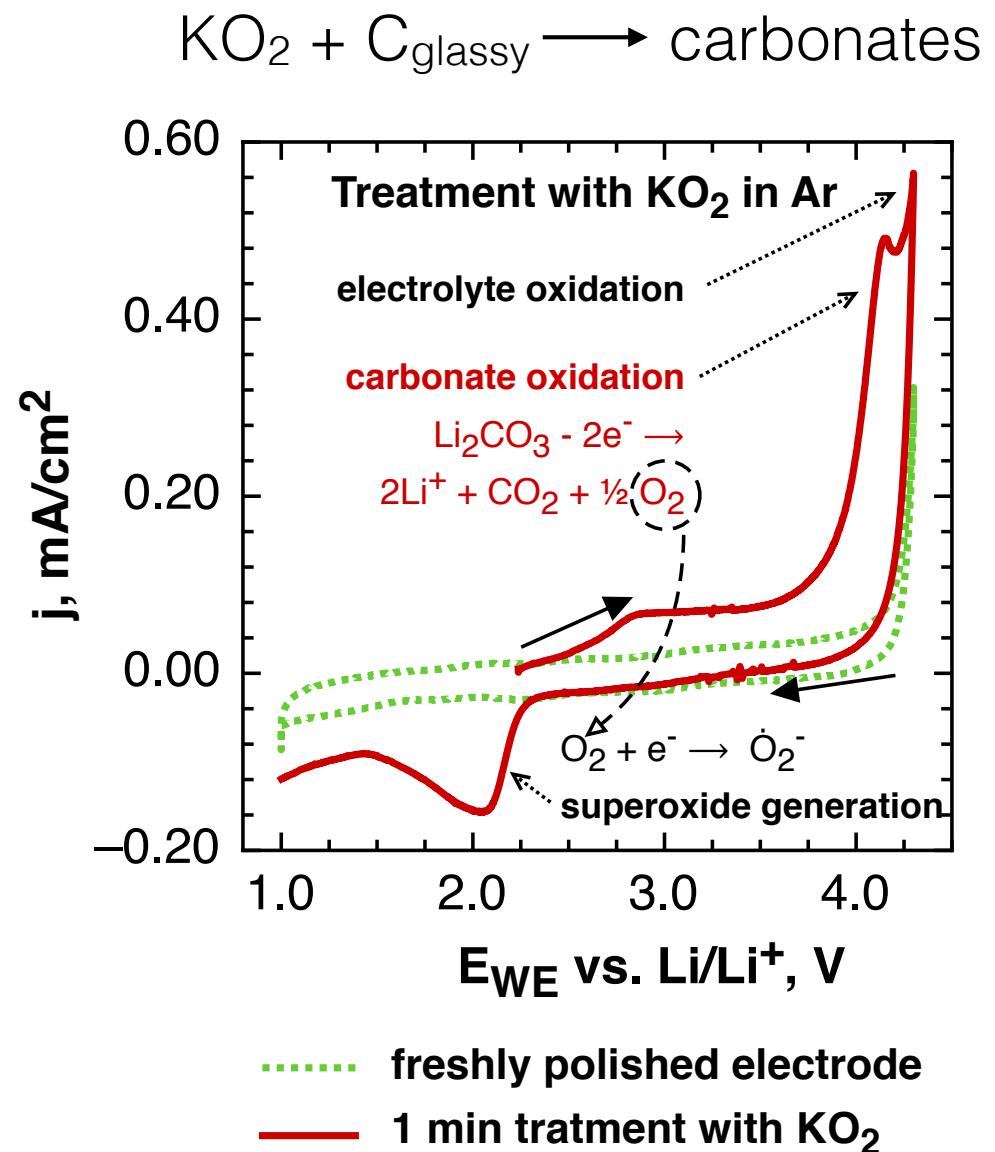
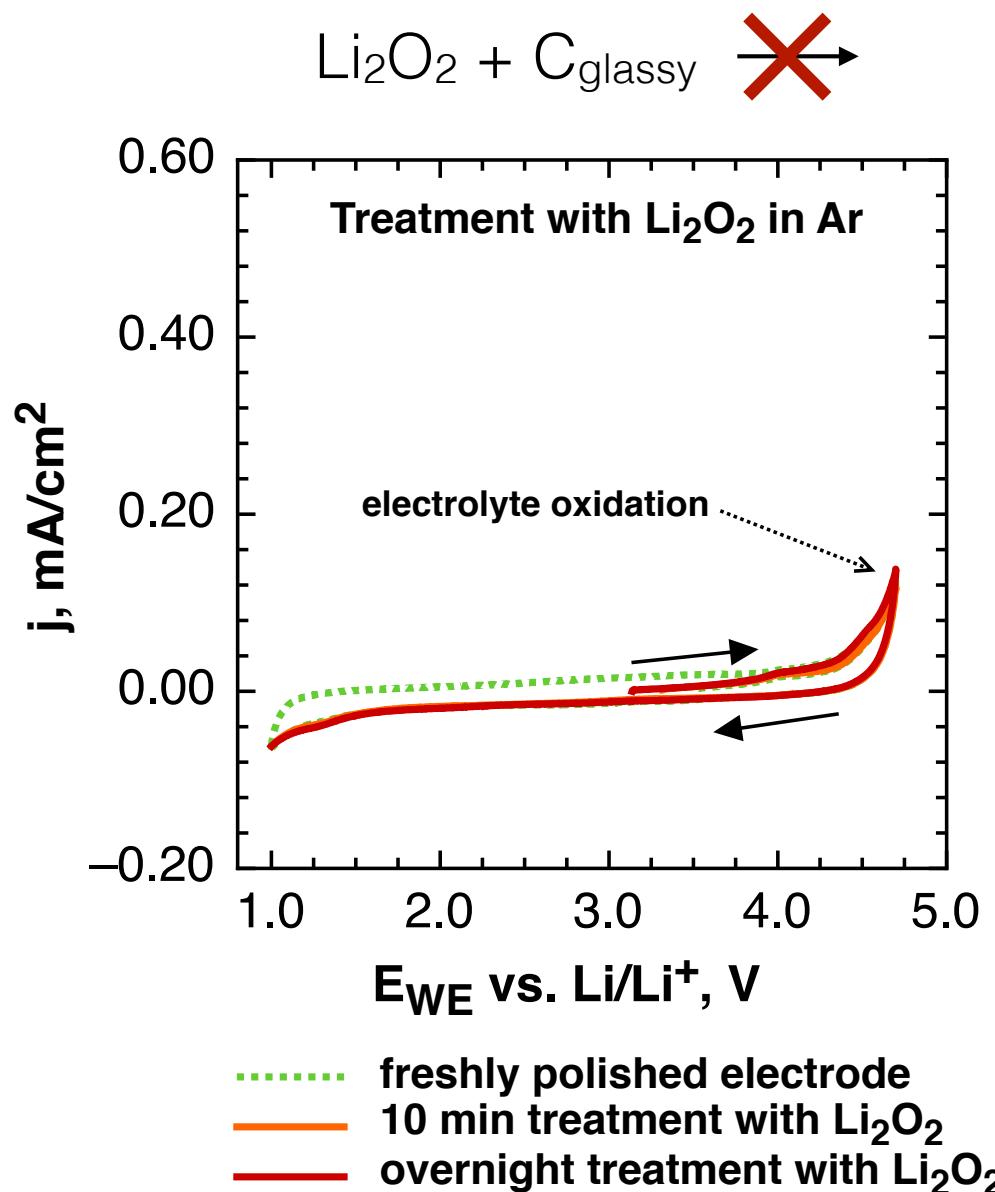
B. McCloskey et al. // J Phys Chem Lett 3 (2012)

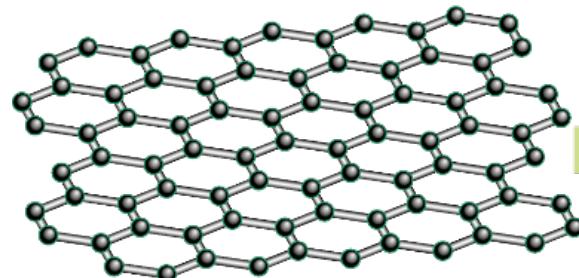


Dr. Elmar Kataev

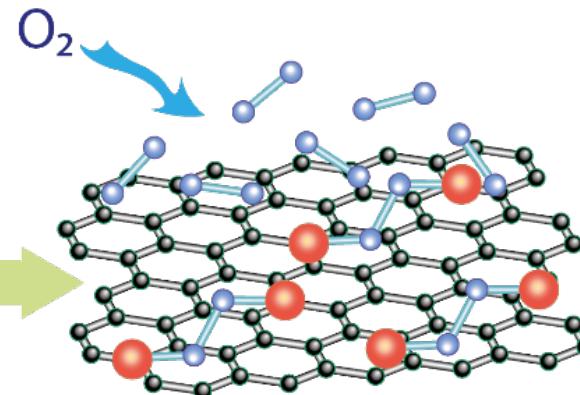
ACS Nano 2015 9(1), 320

В чем причина деградации углерода?

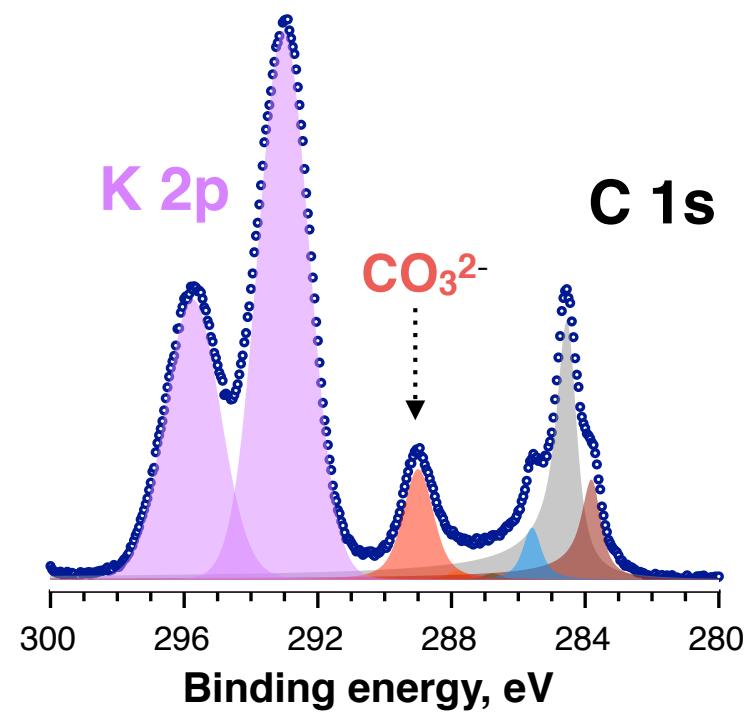
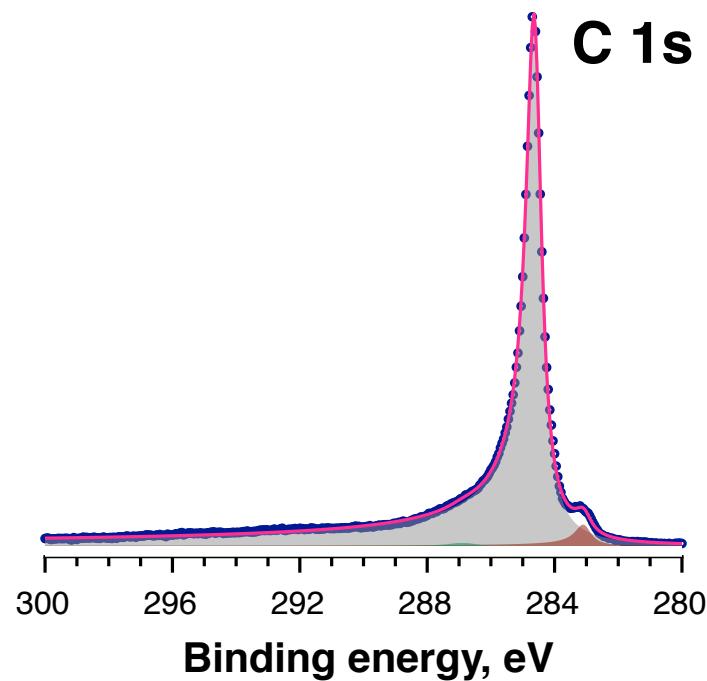




graphene synthesis
on Ni (111)



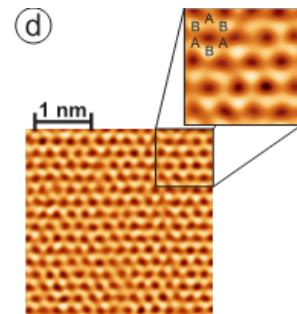
KO₂ synthesis
(K deposition in 10⁻⁴ mbar O₂)



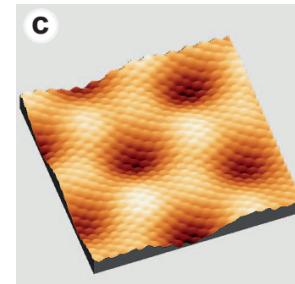


Dr. Elmar Kataev

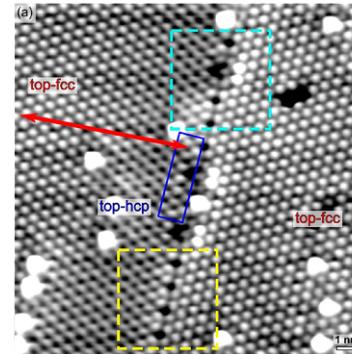
Graphene/Co (0001) Graphene/Ir (111) graphene/Ni (111) Graphene/Cu



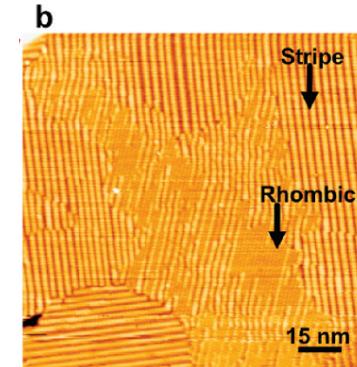
Nano Lett. 2015,
15, 2396 –2401



Voloshina, E.N.
Sci. Rep. 3, 1072

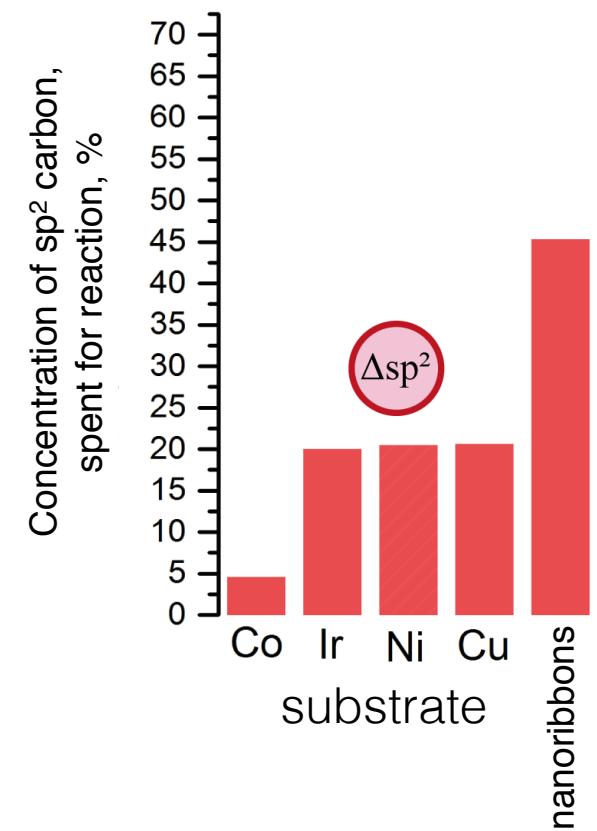
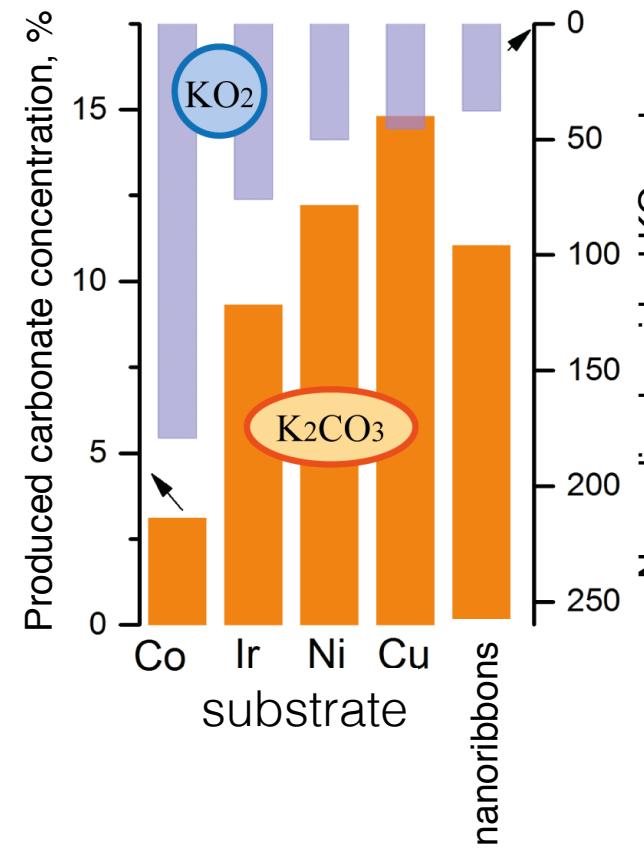
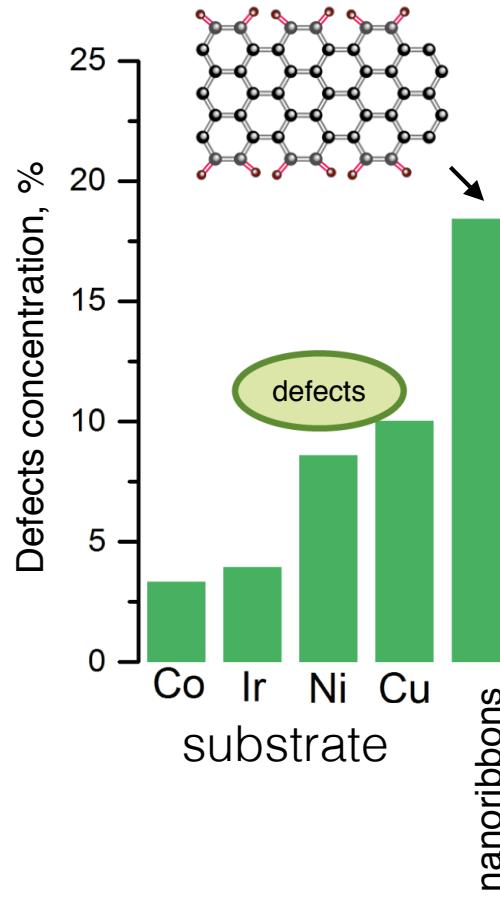


J. Phys. Chem. Lett.
2014, 5, 467 –473

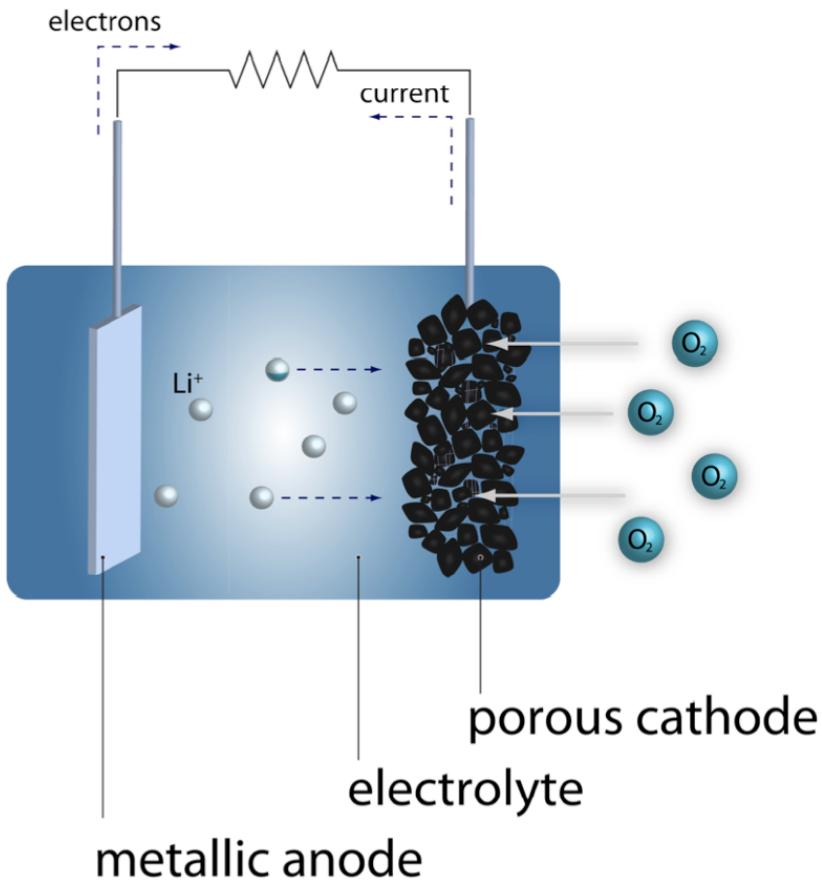


ACS Nano, 2011, 5 (5),
pp 3607–3613

Increasing amount of native defects



Альтернативы углероду?

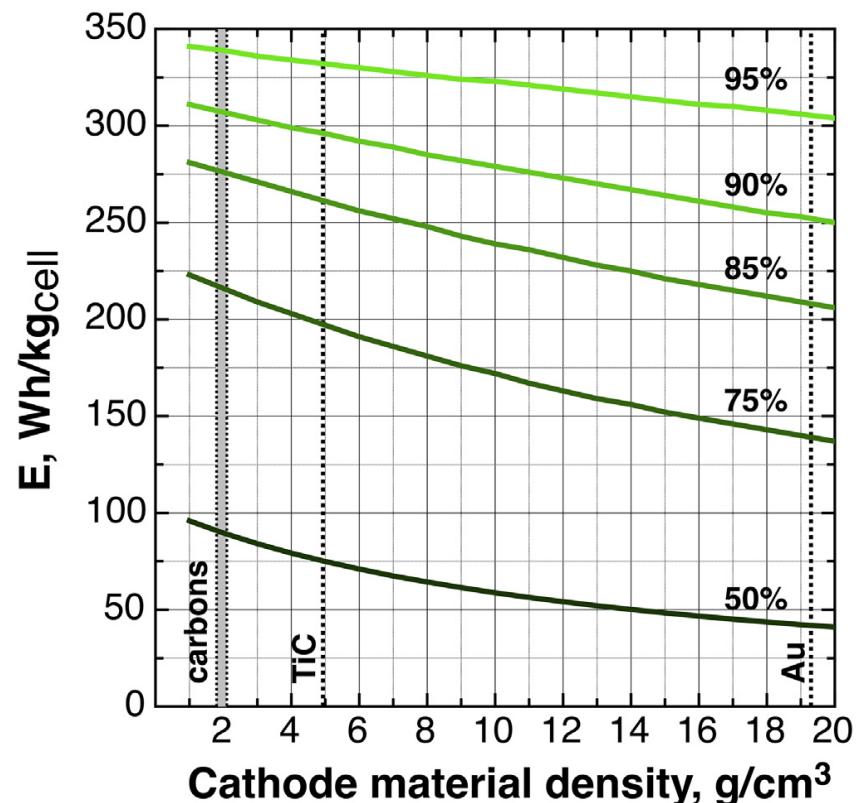


Artem Sergeev

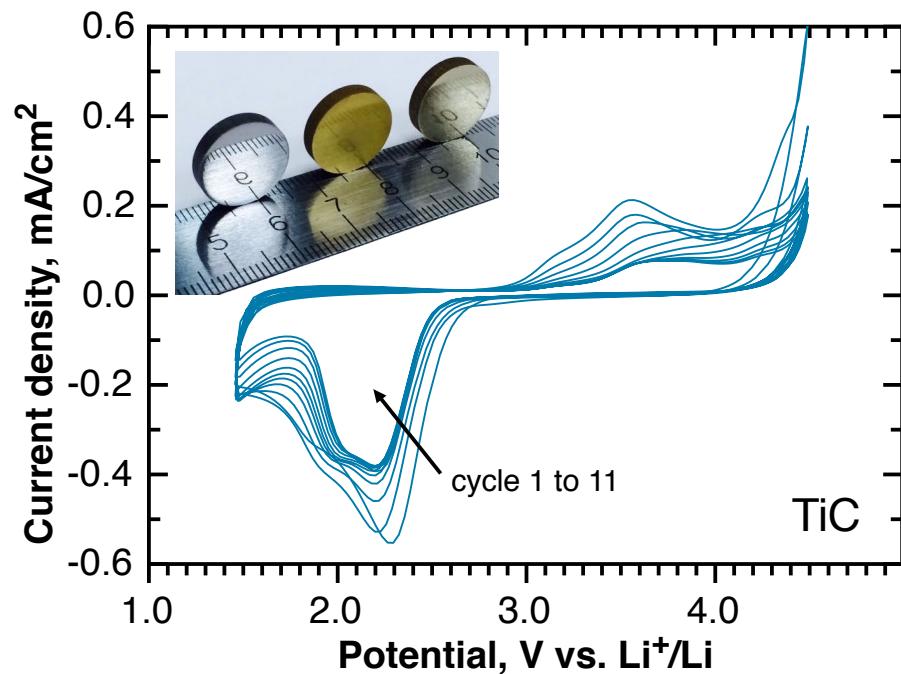
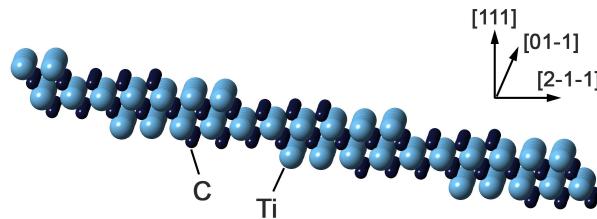
J. Power Sources **2015**, 279(C), 707–712

Требования для положительного электрода:

- низкий удельный вес
- высокая электронная проводимость
- высокая пористость
- (Электро)химическая стабильность



TiC

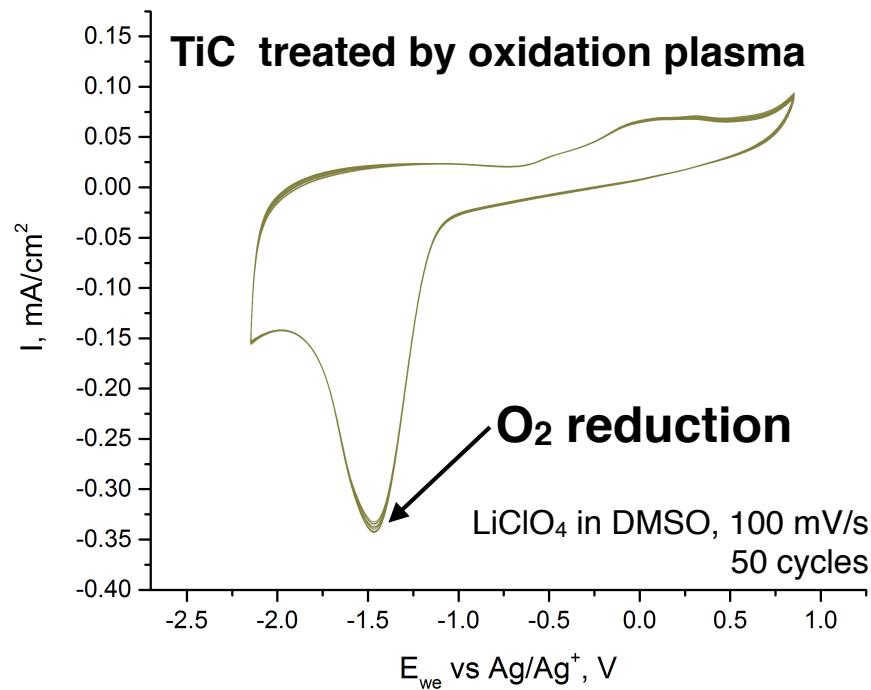
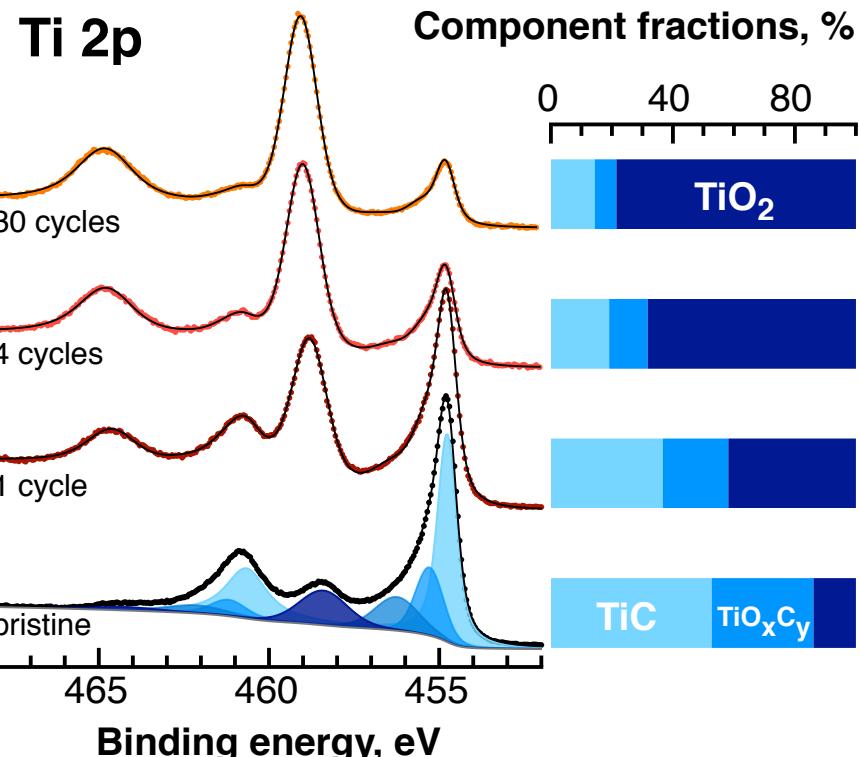


LiClO_4 in DMSO, 100 mV/s



Anna Kozmenkova

Chem. Mater. **2016**, 28 (22), 8248–8255



Dr. Axel Knop-Gericke



Dr. Boris Senkovskiy



Dr. Juan Velasco-Velez



MAX-PLANCK-GESELLSCHAFT
Fritz-Haber-Institut

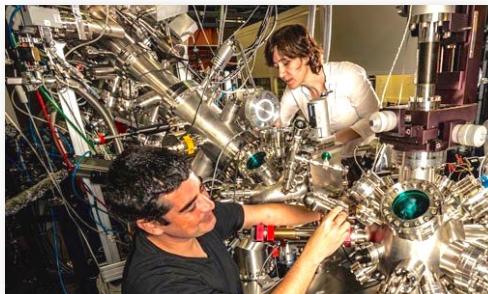


Dr. Denis Vyalikh



Dr. Michael Havecker

Dr. Virginia Pérez-Dieste



Dr. Carlos Escudero



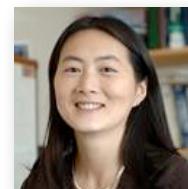
Moscow State University



Saint Petersburg State University



Dr. Dmitrii Usachev



Prof. Yang Shao-Horn



University of Cologne



Prof. Alex Grueneis



Dr. Matteo Amati



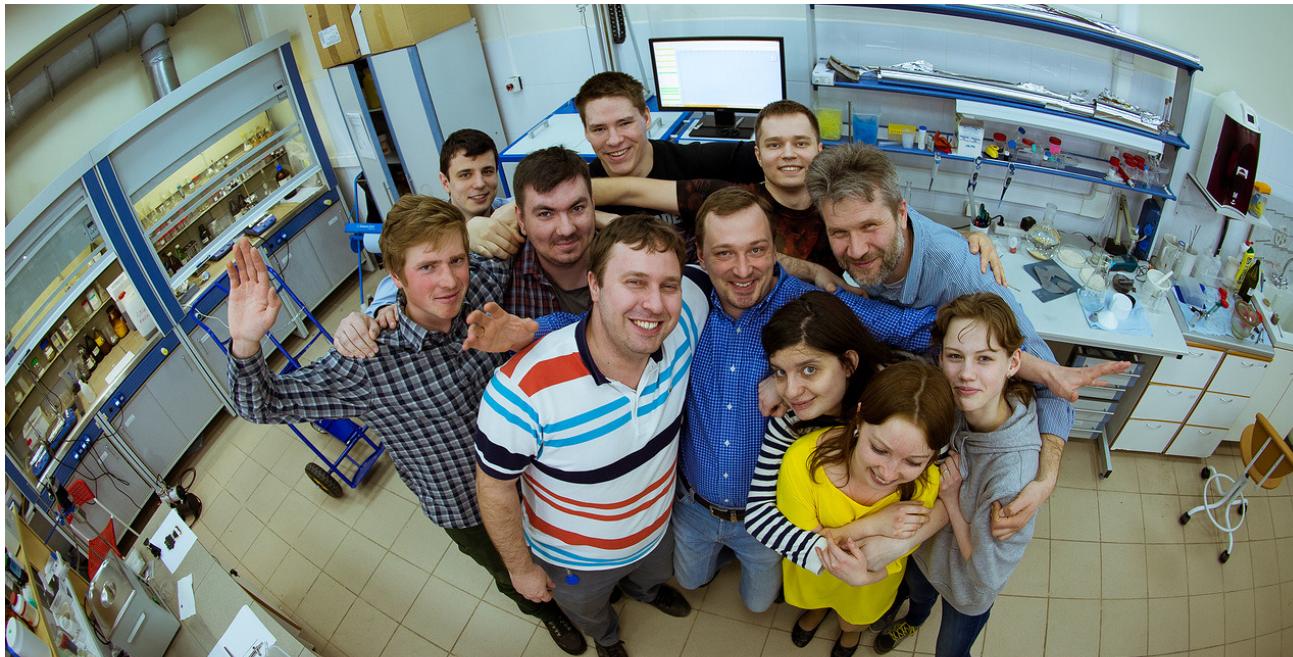
Dr. Luca Gregoratti



Dr. Alexey Barinov



daniil.itkis@gmail.com



Министерство образования и науки
Российской Федерации



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für Bildung
und Forschung

 **SYNESTESia**
synchrotron and neutron studies for energy storage

Skolkovo Tech

Skolkovo Institute of Science and Technology

HZB Helmholtz
Zentrum Berlin



FM Lab

 **G-RISC**
German-Russian
Interdisciplinary
Science Center

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and FM Lab llc. company for the equipment
provided.

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G-RISC Centre of Excellence.