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High-Performance Silicon/Graphene Composite for Electrochemical Energy Storage

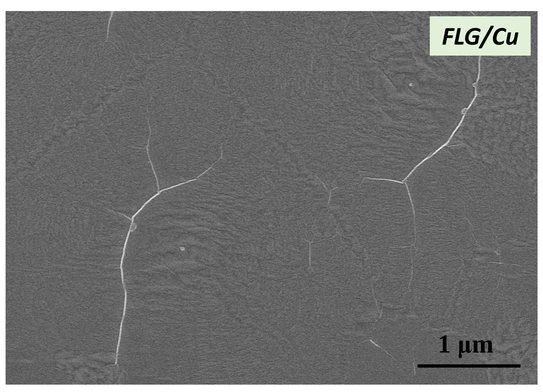
Farjana J. Sonia [1,*], Golam Haider [1], Martin Müller [2], Milan Bousa [1], Antonín Fejfar [2], Martin Kalbáč [1], Otakar Frank [1,†]

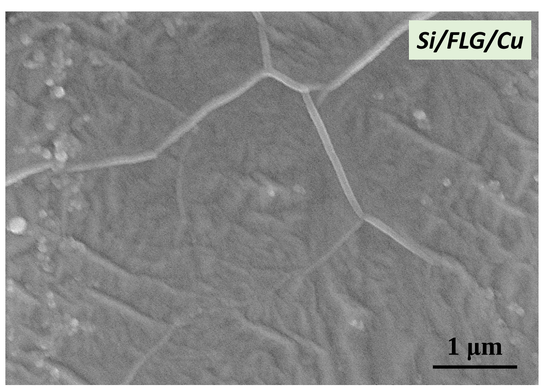
(1) J. Heyrovsky Institute of Physical Chemistry of the Czech Academy of Sciences, 18223 Prague 8, Czech Republic
(2) FZU-Institute of Physics of the Czech Academy of Sciences, 16200 Prague 6, Czech Republic

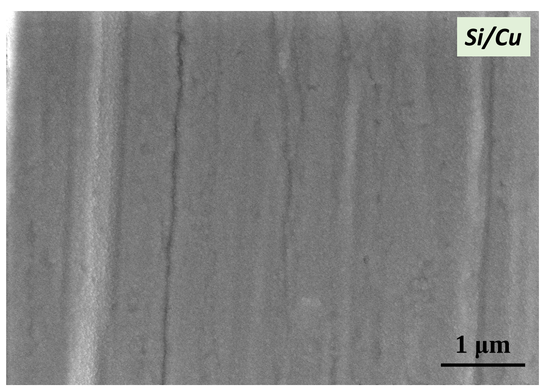
Introduction

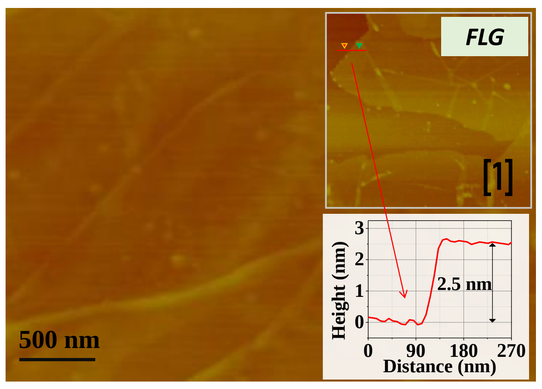
High energy density and power density of Li-ion batteries have made it an excellent energy storage solution for a wide range of applications. However, to fulfil the ever-increasing demand for energy, long cyclic performance and safety of Li-ion battery, exploring new and more efficient electrode materials has been stressed in recent years. Silicon is considered as the most promising replacement of the commonly used graphitic carbon anode material due to very high theoretical Li-storage capacity, earth abundance and better safety aspects. However, severe volume expansion upon lithiation, pulverization from current collector, poor electrical conductivity, unstable solid electrolyte interface layer etc. are the major problems of Si anode. In current report, an attempt is made to address these issues by introducing graphene with Si. The graphene not only enhances the effective surface area for Si, but also acts here as a strong backbone to Si and provides smooth electronic conduction path so that Si can withstand volume expansion, sustain more lithiation/delithiation cycles and also provide high power density.

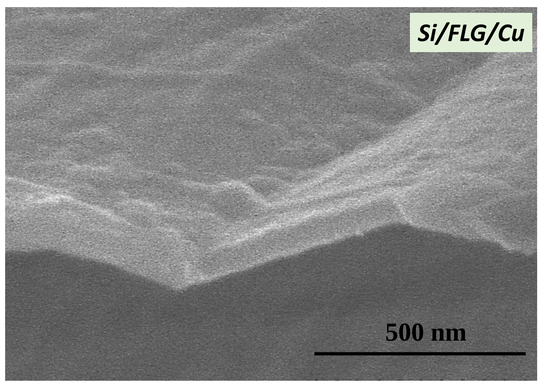
Material Characterization

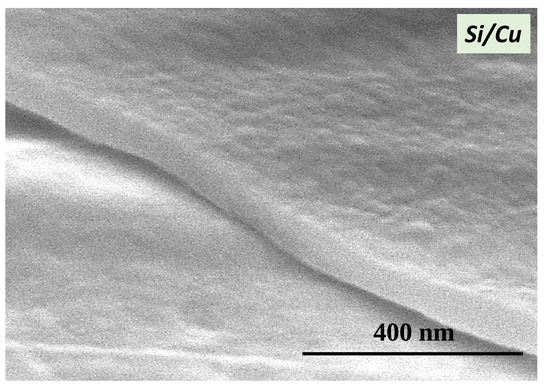




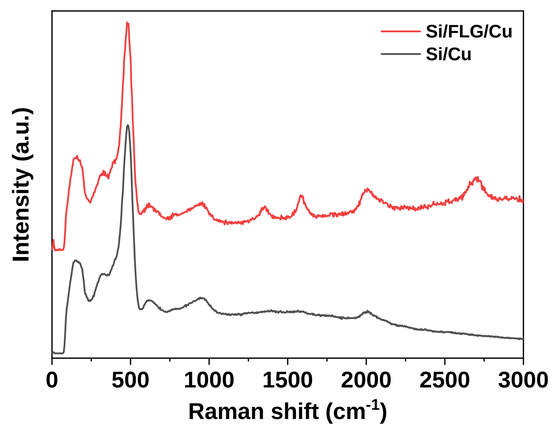






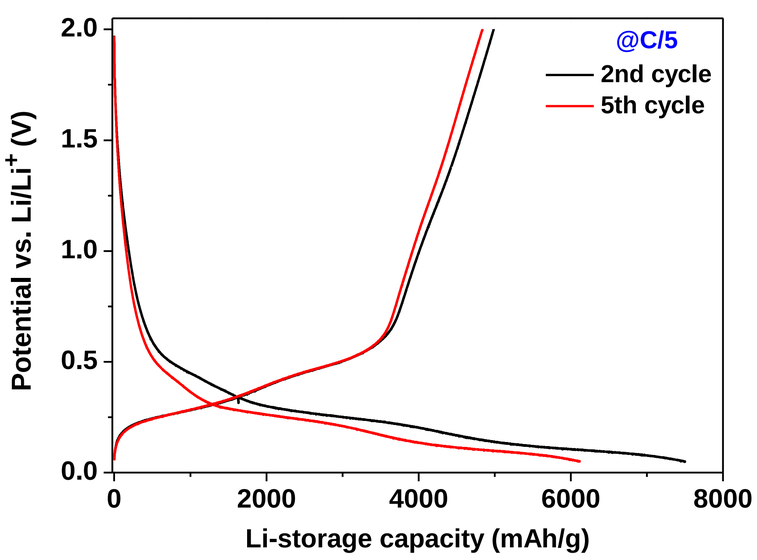


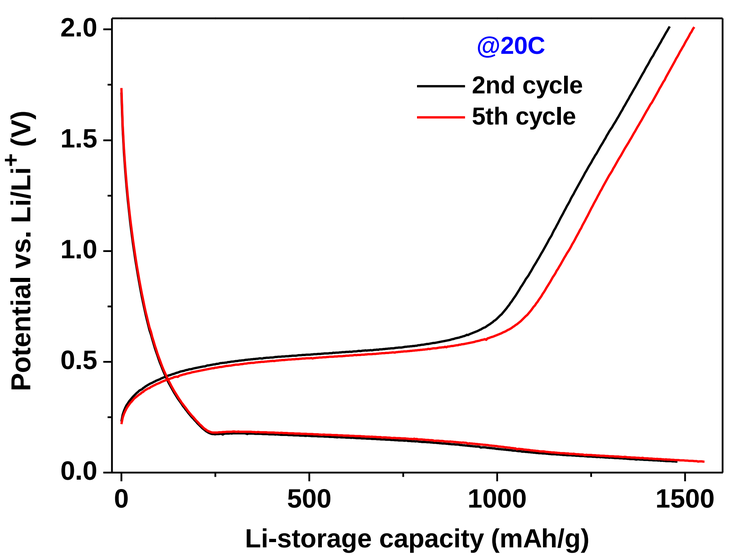
Amorphous Si of thickness ~50nm deposited via plasma-enhanced chemical vapour deposition (PECVD) on few layer graphene (FLG) of ~7 graphene layers and Cu foil

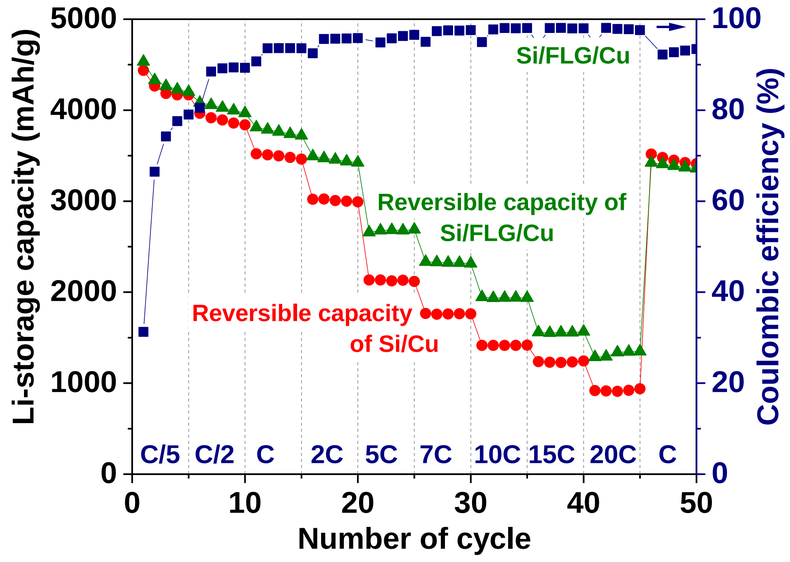


[1] J. Mater. Chem. A 5 (2017), 8662-8679

Electrochemical Li-storage







- ❑ Very high Li-storage capacity of Si/FLG/Cu: reversible (de-lithiation) capacity of ~4000 mAh/g at slow cycling rate C/5
- ❑ Excellent rate capability of Si/FLG/Cu in comparison to Si/Cu: reversible capacity of ~1500 mAh/g at very high cycling rate of 20C
- ❑ High Coulombic efficiency ~98% obtained with Si/FLG/Cu at current rates >5C

Contact Persons

* jaishmin.farjana@jh-inst.cas.cz
(Presenting author)

† otakar.frank@jh-inst.cas.cz

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