Synthesis and applications of graphene materials

Wencai Ren

Shenyang National Laboratory for Materials Science, Institute of Metal Research, Chinese Academy of Sciences, Shenyang 110016, P.R. China

wcren@imr.ac.cn

Great achievements have been made in graphene research area since 2004, however, it is still remains a great challenge for realizing large-scale controlled synthesis and real applications of graphene materials. First, we have developed an ambient pressure CVD to synthesize millimeter-size high-quality single-crystal graphene on Pt, proposed a novel electrochemical bubbling method to transfer these domains to arbitrary substrates without destroying the metal growth substrates [1], realized the edge and morphology control of single-crystal graphene domains, observed and explained the edge-dependent growth behavior of graphene, and found an efficient way to heal the defects in graphene and fabricate large-size high-quality single-crystal graphene [2]. Second, we have realized the direct synthesis of a three-dimensional (3D) porous graphene macrostructure by template-directed CVD, which we call graphene foam (GF) [3]. GF consists of a 3D interconnected network of graphene, which is flexible and has high electrical conductivity. As a result, it shows many potential applications such as elastic conductors [3], high-sensitivity gas detectors [4], flexible lithium ion batteries (LIBs) with ultrafast charge and discharge rates [5], lightweight and flexible electromagnetic interference shielding materials [6]. Third, we have developed a highly efficient method to produce high-quality graphene materials at a low cost [7]. With a proto-type production line, 5kg/day graphene materials with a high electrical conductivity (~1,000 S/cm) can be directly produced, which show a great potential for real applications in LIBs, lithium sulfur batteries [8], as well as various composites and functional coatings.

References:

[1] L.B. Gao, W.C. Ren, H.M. Cheng, et al., Repeated growth and bubbling transfer of graphene with millimetre-size single-crystal grains using platinum, ***Nature Communications*** 3, 699, 2012.

[2] T. Ma, W.C. Ren, H.M. Cheng, et al., Edge-controlled growth and kinetics of single-crystal graphene domains by chemical vapor deposition, ***PNAS*** 110 (51), 20386-20391, 2013.

[3] Z.P. Chen, W.C. Ren, H.M. Cheng, Three-dimensional flexible and conductive interconnected graphene networks grown by chemical vapour deposition, ***Nature Materials*** 10 (6), 424-428, 2011.

[4] F. Yavari, W.C. Ren, N. Koratkar, et al., High sensitivity gas detection using a macroscopic three-dimensional graphene foam network, ***Scientific Reports*** 1, 166, 2011.

[5] N. Li, W.C. Ren, F. Li, H.M. Cheng, et al., Flexible graphene-based lithium ion batteries with ultrafast charge and discharge rates, ***PNAS*** 109 (43), 17360-17365, 2012.

[6] Z. P. Chen, W. C. Ren, H. M. Cheng, et al., Lightweight and flexible graphene foam composites for high-performance electromagnetic interference shielding, ***Advanced Materials*** 25 (9), 1296-1300, 2013.

[7] S.F. Pei, W.C. Ren, H.M. Cheng et al., A method to synthesize high-quality graphene materials, **Chinese Patent 201110282370.5**.

[8] G.M. Zhou, S.F. Pei, F. Li, H.M. Cheng, et al., A graphene-pure-sulfur sandwich structure for ultrafast, long-life lithium-sulfur batteries, ***Advanced Materials*** 26 (4), 625-631, 2014.