PL-1.3

Applying the Negligible Mass of Graphene Aeromaterials: Repeatable Air Explosions and Instant Sterilization

Rainer Adelung
Institute for Material Science, Kiel University, Germany

Aeromaterials in the form of Aerographite have been discovered and created around 10 years ago and were reported in Advanced Materials [1]. Beside the public excitement about the in those days labeled “lightest Material”, the material has unique properties that differ from other lightweight materials like Aerogels, which is caused by their design. Aerographite is constructed in a template approach on a framework of tetrapodal ZnO, that is shaped by sintering into a continuous macroscopic branched network. The ZnO network consist of ZnO rods with diameters of ~1-3 μm and length of typically 10-20 μm between the next intersection. Removal of the template follows in Aerographite during the deposition process: while a carbon layer is wrapped around the ZnO Network, the ZnO is etched away by hydrogen. Thus, a network of free-standing nanoscale thin films rolled up into microscale diameter tubes with tube length of 10-20 μm and macroscopic expansion on the cm scale is created. Later on, further CVD grown variants like the AeroBN [2] or Aerogalnite [3] were created. By wet chemical deposition of 1D and 2D nanomaterials, carbon nanotube tube networks [4] or Aerographene samples [5] were manufactured as well.

Two structural features of the Aeromaterial are most prominent: the low mass, mainly caused by the nanoscopic wall diameter and the large free volume which is interconnected and, in its way, special, as it is free from narrow restrictions. As a thought experiment a sphere with an expansion of ~1 μm can be transported without collisions through the material from one side to the other on a relative straight pathway. The combination of low mass tubular micrometers a nd distances of tenth of micrometers has the immediate consequence that light is scattered in a very efficient manner. This explains the high light adsorption in aero graphite [1] as well as the highly efficient laser light scattering in AeroBN [2].

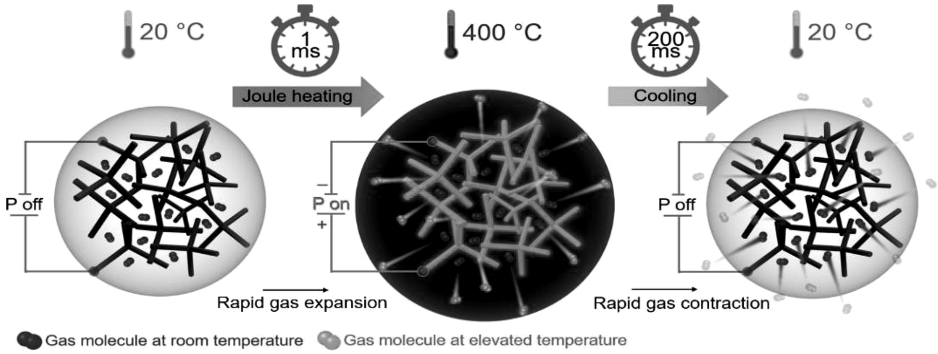

Illustration of an EPRAE (Electrically powered air explosion), see F. Schütt et al. Mat. Today, in press, doi.org/10.1016/j.mattod.2021.03.010

The combination of the structural features of Aeromaterials, the interconnected large free volume and the low weight are employed for a powerful pneumatic actuator. Low mass means low heat capacity, which results in reaching high temperatures with relative low power. Heating rates about 500.000 °C/s can be reached – consequently, even under ambient conditions, temperatures can be reached that result in a significant air expansion. These lead to explosion like air bursts from the Aeromaterial. Other than combustion processes, no chemistry is involved, meaning the “explosion” can be repeated after fractions of seconds without any fuel, see figure below. The talk will present various applications reaching from aero-ear-headphones over actuators that carry the 10.000 times its own weight, miniaturized air/water pumps to disinfection of filters in fractions of seconds for complete sterilization.

References

1. M. Mecklenburg et al. Advanced Materials 24, 3486 (2012)
2. F. Schütt et al. Nature Communications 11, 1437 (2020) ,
3. I. Tiginyanu et al. Nano Energy 56, 759 (2019)
4. F. Schütt et al. Nature Communications 8, 1215 (2017)
5. F. Rasch et al. ACS Applied Materials and Interfaces 11, 44652 (2019)