Chapter 5
Trend and Scope Beyond Traditional Supercapacitors

Primitive type supercapacitors that were made of pure carbon or carbon derived electrode materials have gone through rapid evolution since few decades. Most of these traditional supercapacitor devices are of symmetric nature, i.e. both electrodes are fabricated from the same material which reduces any chances of enhancing the working potential window. The first stage evolution took place with the concept of taking two different materials as electrodes to form an asymmetric supercapacitor device which not only will provide the option for wider potential window but also suppress decomposition of electrolytic content (specifically for aqueous based electrolytes). Thus asymmetric supercapacitors are promising storage options and should be put to further research in order to promote its commercial viability. Extensive research should also be done on electrolytic materials as they play a key role in the performance of a supercapacitor device.

Apart from the above asymmetric supercapacitor prototype, further work need to be carried out to try and test the feasibility of various other cost-effective materials as supercapacitor electrodes. As discussed in the previous sections, there are challenges while trying to obtain a system of two electrodes using a suitable electrolytic material. There are other aspects too such as the post-fabrication performance of the supercapacitor device, safety, reliability and stability. Also, more attention is to be devoted towards the development and practical implementation of hybrid supercapacitors by designing a combination of electrodes and electrolyte.

To create a high performance asymmetric and/or hybrid storage device (supercapacitor), there are few key points which should be taken care of;

1. Designing a current collector which should be able to provide excellent contact formation. It should be highly resistant toward any physical and/or chemical hazards. Preferably, a highly conducting, robust, non-corrosive, and flexible material such as metal foam/foil is to be applied as the current collector.
2. Suitable electrode materials for the purpose to fabricate both cathode and anode. For the cathode, a material with high porosity, chemical stability, mechanical/

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tensile strength, superior adsorption capability will be ideal in order to promote EDLC.

In contrast, for the anode, a material with high pseudocapacitive/lithium intercalation property, high electrical conductivity would suffice. For ASCs, though metal oxides provide plenty of options to try out, research should be extended toward more promising materials such as metal nitrides having better electrical conductivities which would have significant impact on the supercapacitor performances.

Similar approach toward the futuristic development of lithium storage material is the key to the designing of high power density and energy density supercapacitors which could assist the battery technology to ward off issues of sluggish charge uptake time, overcharging etc. Lithiated metal nitrides and/or lithium compounds are found to be ideal for this purpose.

Furthermore, electrode material synthesis is an important aspect which should be carried out with utmost care. Most of the materials that have been grown indirectly using substrate/template assisted growth can be successfully replaced with those grown directly using various substrates and can directly be taken as current collector/electrode assembly. That would bring much better adhesion between the both which is desired for a supercapacitor device.

3. Judicious selection of electrolyte materials (liquid, gel or solid) is also critical as it would have significant impact on the stability and ionic conductivity of the solid electrolyte interphase (SEI). The compactness, rigidity and long cycle life of a supercapacitor device will be determined by the type of electrolyte used. For supercapacitors employing liquid electrolytes, a suitable separator should be selected to facilitate ion/charge transportation and for maintaining a barrier between the two electrodes and protect the device from short circuit.
4. Though rigorous research has been done on huge number of metal oxides as cheap and high performance pseudocapacitive material, extended interest should be vested in few promising compounds such as metal nitrides, metal borides etc. which would facilitate the selection and development of efficient high performance supercapacitor electrodes.