CHAPTER IX

CONCLUSION

In this dissertation, we have demonstrated the broad applicability of electrophoretic deposition (EPD) as a technique to assemble nanoparticles into macroscopic solids. With a framework to analyze suspensions of nanoparticles, we were able to predict the EPD conditions—applied voltage, electrode spacing, and deposition time—necessary to obtain a deposited film of the nanoparticles. By tuning the aqueous suspension of exfoliated graphene oxide (eGO), we were able to manipulate not just the film deposition location of those nanoparticles, but also the microstructure they assumed as they formed the film.

In doing EPD from aqueous suspensions and nonpolar, hexane suspensions, we were able to identify appropriate polymers that enabled us to implement the sacrificial layer technique that was hypothesized at the onset of this project. By combining EPD with the use of a sacrificial layer, we believe that we have a path for constructing a wide assortment of macroscopic solids from nanoscale building blocks.

As an immediate extension of this dissertation work, we believe an interesting avenue of study will be the investigation of the internal arrangement of nanoparticles in these solids. Small angle X-ray scattering is one technique that has been used with success to determine ordering of nanoparticles, not their individual atoms, in a solid. Another approach, which could be relevant to the (eGO) material with its different microstructures, is neutron scattering. Neutron scattering has been used to determine atomic spacing in carbonaceous materials, and could reveal further insights about electrophoretically prepared solids with nanoscale carbon building blocks.

Looking further forward, two larger project ideas emerge from this report. The first idea concerns heterostructures and composites of the various nanomaterials. In a previous work [68], we showed how nanoparticles suspended in hexane could be electrophoretically deposited in alternating layers with carbon nanotubes deposited from aqueous suspension. The ability to prepare films with microscale voids, such as the eGO brick films, means that other nanoparticles could infiltrate these films, not just form a distinct layer adjacent to the films. For applications such as photovoltaic devices, infiltration would allow increased surface area for interaction while graphene could offer enhanced charge transfer compared to carbon nanotubes because of access to the sheet edges.

The second idea concerns the free-standing films of eGO sheets. The form-function relationship in these films could be explored by performing transport measurements on the films. With a greater understanding of how the arrangement of sheets (the microstructure) affects transport, it would be possible to design materials for lightweight electrodes in batteries and capacitors. The ability to fabricate transparent, flexible films with tunable conductivity would also have relevance for applications such as touch displays in the next generation of electronics.