Multi-valent interactions in systems of polyelectrolytes can exhibit dramatic, non-monotonic effects, for example, switching forces from repulsive to attractive, and back to repulsive again, in some cases. We have been studying these patterns of behavior with the surface forces apparatus (SFA) and with electrochemical methods, such as cyclic voltammetry, which enables the quantitative determination of the number of multi-valent ions residing in thin layers of charged polymers. At fixed ionic strength, all cause strong shrinkage and condensation of poly(styrene sulfonate) brushes over a narrow range of ratio multi-valent to mono-valent ions. When the multi-valent ion is an oppositely charged polymer, new fluid phases can form. We have clarified the quantitative aspects of the phase diagram for a simplified polyelectrolyte complex system. See Figure 1. Charged blocks in copolymers leads to materials with new types of ordered phases. Effects of these multi-valent interactions on supermolecular and biomolecular assembly will be discussed. There are many possibilities for the creation of new materials based on electrostatic assembly involving multi-valent interactions.

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In 2011, Matthew Tirrell was appointed as the founding Pritzker Director and Dean of the Faculty of the Institute for Molecular Engineering and established the first University of Chicago engineering program, which he continues to oversee. Prof. Tirrell simultaneously served as Deputy Laboratory Director for Science (2015 - March 2018) and Chief Research Officer (2016- March 2018) at Argonne National Laboratory. Immediately prior to joining the University of Chicago, he was the Arnold and Barbara Silverman Professor and Chair of Bioengineering at the University of California, Berkeley, with additional appointments in chemical engineering and materials science & engineering, as well as a Faculty Scientist appointment at the Lawrence Berkeley National Laboratory. Dr. Tirrell completed ten years as Dean of Engineering at the University of California, Santa Barbara on June 30, 2009. From 1977 to 1999, he was on the faculty of Chemical Engineering and Materials Science at the University of Minnesota, where he served as department head from 1995 to 1999. Tirrell received a B.S. in Chemical Engineering at Northwestern University in 1973 and a Ph.D. in 1977 in Polymer Science from the University of Massachusetts. He has co-authored more than 350 papers and one book and has supervised over 80 Ph.D. students. Professor Tirrell is a member of the National Academy of Engineering, the American Academy of Arts & Sciences and the Indian National Academy of Engineering, and is a Fellow of: the American Institute of Medical and Biological Engineers, the AAAS, and the APS.