Examination of thin film growth using supersonic molecular beams and *in situ* real time X-ray synchrotron radiation: from organic small molecule semiconductors to transition metal dichalcogenides

James R. Engstrom
Robert F. Smith School of Chemical and Biomolecular Engineering
Cornell University
Ithaca, NY 14853

The study of thin film growth using real time techniques has always represented an important challenge to the experimentalist. Over the past several years our group has been employing supersonic molecular beam techniques and *in situ* real time X-ray synchrotron radiation to examine a variety of systems in two important emerging areas: organic small molecule semiconductors and transition metal dichalcogenides (TMDs). In a number of cases we have supplemented the information we obtain from X-ray scattering, with results from *in situ* real time X-ray fluorescence, and atomic force microscopy. In this presentation we will review some of our more intriguing findings. We will address issues such as: does the sequence of deposition matter concerning the growth of heterostructures involving two small molecule organic semiconductors? do lower growth rates and higher substrate temperatures always produce smoother thin films? and in cases where both a thin-film and bulk phase form, which grows first? The growth of thin films of TMDs has attracted a great deal of interest lately, yet *in situ* real time studies of these materials are few and far between. We will show that *in situ* X-ray synchrotron radiation is a powerful probe of the growth of these materials, and we will show for the first time direct, real-time observation of layer-by-layer growth of a TMD 2D semiconductor.