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PULSED PLASMA SYNTHESIS OF ELECTRICALLY CONDUCTIVE THIN FILMS

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The use of a variable duty cycle pulsed plasma, in lieu of the conventional continuous-wave (CW) approach, has been shown to provide enhanced film chemistry controllability during polymeric synthesis. In the present case, the pulsed plasma technique has been employed to synthesize high conductivity polymeric films from monomers such as pyrrole, thiophene and aniline. Although, these have been many reported studies of plasma polymerization of these monomers, there prior studies, utilizing CW conditions, have resulted in films of relatively low conductivities (i.e., generally lower than 10^{-6} S/cm). Conductive films require retention of the aromatic ring systems of the above noted monomers, coupled with formation of linear, polyconjugated structures during polymer formation. Based on spectroscopic evidence provided in the CW studies, it is clear that relatively little retention of the aromatic ring system is maintained during polymer formation under the relatively energetic conditions employed in these prior investigations.

In the present study, the polymeric films obtained with these monomers were found to be more conductive as the plasma duty cycle employed during their synthesis was decreased. Interestingly, in each case a sharp increase in film conductivity is observed as the plasma duty cycle is reduced to a low threshold value. These abrupt increases involve several orders of magnitude increase in film conductivities signaling a major structural change in film compositions. The highest conductively films were obtained at plasma duty cycles corresponding to averages power inputs well below the minimum value required to maintain a CW discharge under the same experimental conditions. It was possible to achieve films conductivities as high as 10^{-1} S/cm after appropriate film doping with iodine, as shown in the case of polythiophene. The spectroscopic characterization (XPS and FT-IR) of these films, as well as deposition rates and long term stabilities will be presented.

There are a variety of potential applications for these thin conductive films. An example of one such applications, reviewed in this presentation, would be their use as sensors. It has been observed that exposure of these films to various VOC analytes results in measurable changes in their conductivities. The relative magnitude of these conductivity changes are functions of both the nature of the analyte as well as the plasma duty cycle employed in generating the film. Additionally, it has been observed that deposition of a second film on the conducting polymer can enhance analyte selectively as outlined in this talk.