Objective: The goal of this project is to develop low temperature solution-based approaches for producing planar ZnO films and nanowire arrays with controllable conductivity. The students will also explore compatibility of synthesis processes with ZnO deposition on flexible substrates. Success would be a critical step toward ZnO-based flexible solar cells.

Prior Background: ZnO has a long and rich history of use in optical and an electronic applications extending from catalysis to sunscreens. The mentors have an NSF supported ongoing collaborative program with the National Renewable Energy Laboratory aimed at developing polymer/ZnO solar cells. In this research, planar ZnO layers are produced in solution from sol gel precursors. The processing involves a 300C anneal. These layers are then used in devices, or act as the nucleation layer for subsequent solution grown ZnO nanowire arrays which are also used in devices. While the team has a great deal of expertise in ZnO synthesis, a key issue involves controlling the conductivity of the ZnO. As prepared, the sol gel ZnO is highly insulating. Being able to tailor the ZnO conductivity would significantly improve its performance in polymer solar cells. A second issue involves the processing temperatures during ZnO synthesis. Since the active layers in this solar technology are intrinsically flexible, if a flexible substrate can be used, solar cells can be manufactured using approaches similar to printing newspapers which would dramatically reduce costs. Many low-cost flexible substrates are not compatible, however, with high anneal temperatures.

Student Expectations: The team will begin by adapting the present ZnO solution-based sol gel process to include dopant species such as Al which can change conductivity. Anneals in various atmospheres designed to eliminate native defects that suppress conductivity will also be explored. Published approaches will guide the work. Hall effect measurements will be used to characterize conductivity and mobility as dopant concentration and anneal condition are systematically changed. Atomic Force Microscopy (AFM) will be used to investigate grain structure in the films. Once conducting material can be produced, the students will research substrates routinely used for flexible solar cells to determine compatibility with the ZnO synthesis process and attempt to lower the sol gel processing temperature to make it compatible with the substrates. Once flexible ZnO can be produced, ZnO nanowire arrays will be grown on the substrates, characterized using Scanning Electron Microscopy (SEM), and provided to graduate students who will collaborate in fabricating solar cells from the material.

Supervision Plan: The students will be an integral part of a team composed of the mentors and graduate students working on ZnO solar cells. Two graduate students, Darick Baker and Jamie Adamson, will be available for day to day advice. The team will report progress in biweekly group meetings of the full team working on the ZnO solar cell project.

Resources: The students will work in well-equipped labs on the fourth floor of Meyer Hall. These contain all of the chemical, thermal, optical, and thin-film processing hardware needed for
sample preparation. All of the analytical equipment needed for the study is housed in Meyer Hall or Hill Hall and is in good working condition. Materials, supplies, and shared facilities expenses will be covered by the NSF grant supporting the ZnO/polymer project.

Technical References