**GENERAL INFORMATION**

Program sponsor: Princeton Environmental Institute

Position number: E1KOE1

Project title: Binary Transition-metal Oxide Electrocatalysts for the Oxygen Evolution Reaction

Organization/research group: Koel Group

Primary location(s) of internship: Princeton University

Additional cities and/or countries to be visited (if applicable): n/a

Note: If this internship is located in a country with an International SOS risk rating of High or Extreme, final candidates must participate in a travel review process overseen by the Travel Oversight Group (TOG), and obtain safety guidance prior to departure. The University reserves the right to revoke support and funding for travel at any time there has been a significant deterioration in the safety and security conditions surrounding travel arrangements, or in the sector of the country, or countries, where travel is to occur.

**FACULTY SPONSOR(s)/HOST INFORMATION**

Name(s): Bruce E. Koel

University Department(s): Department of Chemical and Biological Engineering

E-mail: bkoel@princeton.edu

Phone: 609-258-4524

Website: princeton.edu/cbe/people/faculty/koel/group/

**INTERNSHIP/RESEARCH PROJECT INFORMATION**

Internship/project description:

This project involves studies of the oxygen evolution reaction (OER) on Co and Ir-based oxide electrocatalysts. The efficiency of this reaction must be increased to enable effective solutions to several renewable energy storage and conversion technologies. We will explore the addition of other transitions metals to form binary oxides and increase performance. Students working on the project will gain experience in synthesis of oxide nanomaterials and deposition of oxide thin films, characterizing these materials, and operating a electrochemical (EC) cell to evaluate their performance. Surface-bound intermediates, as well as the oxide materials themselves, will be characterized using in-situ and operando FTIR and/or Raman spectroscopy studies.

Student's role and responsibilities:

The roles and responsibilities assigned to students will depend somewhat on their backgrounds, skills and career goals. Experimental work will involve assisting and carrying out independent work including: i) synthesizing composite Co and Ir based composite electrocatalysts; 2) characterizing the films and surfaces of these materials using spectroscopy, microscopy, diffraction, imaging, and other analytical techniques; 3) carrying out in situ and operando FTIR and Raman analysis of working electrocatalyst surfaces; and 4) measuring performance with an electrochemical cell and evaluating the electrochemical properties of catalyst samples.
**Internship/project learning objectives:**
Students participating in this project will be able to operate instrumentation and interpret results from several materials characterization tools, including X-ray diffraction (XRD), scanning electron microscopy (SEM), Raman spectroscopy, and X-ray photoelectron spectroscopy (XPS). In addition, they will learn how to synthesize metal oxide materials and films using wet chemistry and physical vapor deposition (PVD) techniques. Student will also learn how to apply and interpret electrochemical measurements, such as cyclic voltammetry (CV) and electrical impedance spectroscopy (EIS), to determine electrochemical properties of catalyst samples.

**PROGRAM REQUIREMENTS**

**Academic background and any course pre-requisites:**
Preferred: Junior year completed with major in Chemistry, Engineering discipline, or Physics

**Technical skills:**
Basic laboratory skills and chemical laboratory proficiency. It is a plus if candidate has some training with electron microscopy or clean room access.

**Additional training(s):**
Safety training

**Equipment:**
none

**Physical demands:**
none

**Language abilities/competencies (if applicable):** n/a

**Additional information about the internship/project:**
Selected students will need to complete lab safety training prior to the start of the internship.

**INTERNATIONAL TRAVEL REQUIREMENTS (if applicable)**

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<thead>
<tr>
<th>Visa(s) required?</th>
<th>Research permit/pass required?</th>
<th>Immunizations required?</th>
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<tbody>
<tr>
<td>Yes ☐ No ☐</td>
<td>Yes ☐ No ☐</td>
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</tbody>
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**INTERNSHIP/PROJECT SUPERVISOR(S)**

**Name and title of primary supervisor:** Bruce E. Koel
**Email:** bkoel@princeton.edu
**Phone:**

**Name and title of additional supervisor, if applicable:** n/a

**E-mail:**
**Phone:**

**PROGRAM DATES AND FUNDING INFORMATION**

<table>
<thead>
<tr>
<th>Weekly Stipend: $500</th>
<th>Number of Positions Available: 2</th>
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<tbody>
<tr>
<td>Tentative Start Date (mm/dd/yyyy): 06/10/2019</td>
<td>Number of Weeks: 10</td>
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<tr>
<td>Tentative End Date (mm/dd/yyyy): 08/16/2018</td>
<td><strong>Note:</strong> PEI funding is for full-time work, 35 hours per week minimum, and for a period of at least 8 continuous weeks.</td>
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**Application Deadline:** January 11, 2019