Betty A. and Donald J. Baumann Family Scholarship Fund Application Form

1. **Name and NetID**

Andrew Wegner; ajw91438

2. **Chemistry faculty research director**

Dr. Erin Gross

3. **Proposal title**

Optimization of Au-plated carbon electrode-based biosensors.

4. **Proposal description. Please limit the proposal to about 500 words and include figures as appropriate. Your proposal should briefly outline the overall project and its goal(s). If you have previous results related to your proposed project, concisely summarize those results and describe what you expect to accomplish during the time frame of the scholarship.**

Folding-based nucleic acid electrochemical biosensors offer an inexpensive and fast method for clinical measurements and disease diagnostics. Previous research in our lab fabricated electrochemiluminescent (ECL) nucleic acid biosensors using commercial gold electrodes. This method allows for fast detection, but the gold surfaces require extensive cleaning before modification. To solve this, in situ chip based ECL biosensors can be fabricated with a fresh, easily modifiable gold layer deposited over carbon. The surface can be modified with an alkane thiol to connect the gold to a fluorescently tagged aptamer, allowing for biosensor specificity (see Figure 1). So far, the chronoamperometry method shown in table 1 has optimized total gold deposition, coverage, and quality.

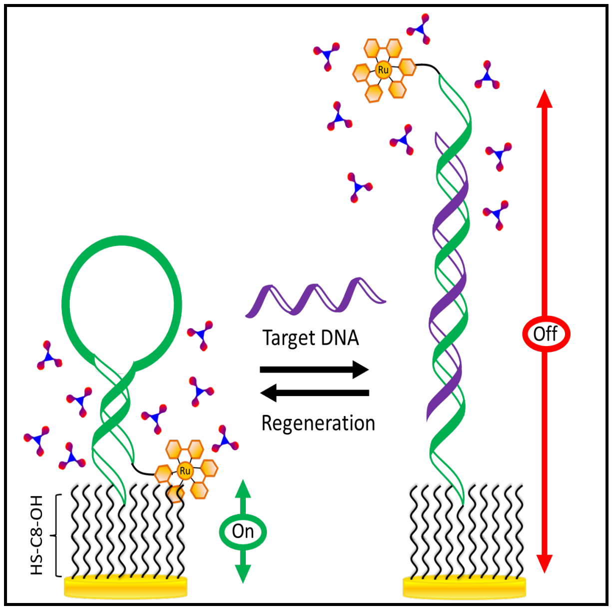

Figure 1: Complete ECL Nucleic Acid Biosensor
This sensor is constructed using a gold base, HS-C8-OH alkane thiol adaptor, DNA aptamer, and a fluorescent tag ($Ru(bpy)_3$). Co-factor tri-n-propylamine (shown in blue) must be present for $Ru(bpy)_3$ to fluoresce. When $Ru(bpy)_3$ is close to the gold, it can undergo excitation and emit a fluorescent signal. After aptamer unwinding, excitation cannot occur because $Ru(bpy)_3$ is too far from the gold. Unwinding only occurs when the aptamer binds to a highly specific complementary nucleic acid sequence.

Table 1: Chronoamperometry Method for Gold Deposition

Parameter	Value
Initial Potential	-0.50 V
High Potential	0.00 V
Low Potential	-0.50 V
Initial Step Polarity	Positive
Number of Steps	6
Pulse Width	10 s
Sample Interval	1.0 s
Quiet Time	2.0 s
Sensitivity	1 e-003 A/V

The amount of gold deposited on the electrode surface is quantized through a surface roughness, or rho value. This is the ratio of the experimental gold surface area to the geometric carbon surface area. Ideal rho values range from 3.8-4.2.[1] Surface roughness results indicate the method outlined in table 1 generates ideal rho values with an approximate 60% success rate (see Figure 2). Scanning electron microscopy (SEM) images show gold covering the entire surface of carbon electrodes (see Figure 3). Cracks are sometimes present, but do not inhibit electrode performance if deposited gold preferentially forms bud nanostructures over dendrite nanostructures. Bud nanostructures can be identified through small, spherical characteristics. Dendrites can be identified by large, branched, pointy, and “pinetree” resembling characteristics. SEM images show gold nanostructures primarily form buds instead of dendrites, indicating these electrodes will provide robust results (see Figure 4).

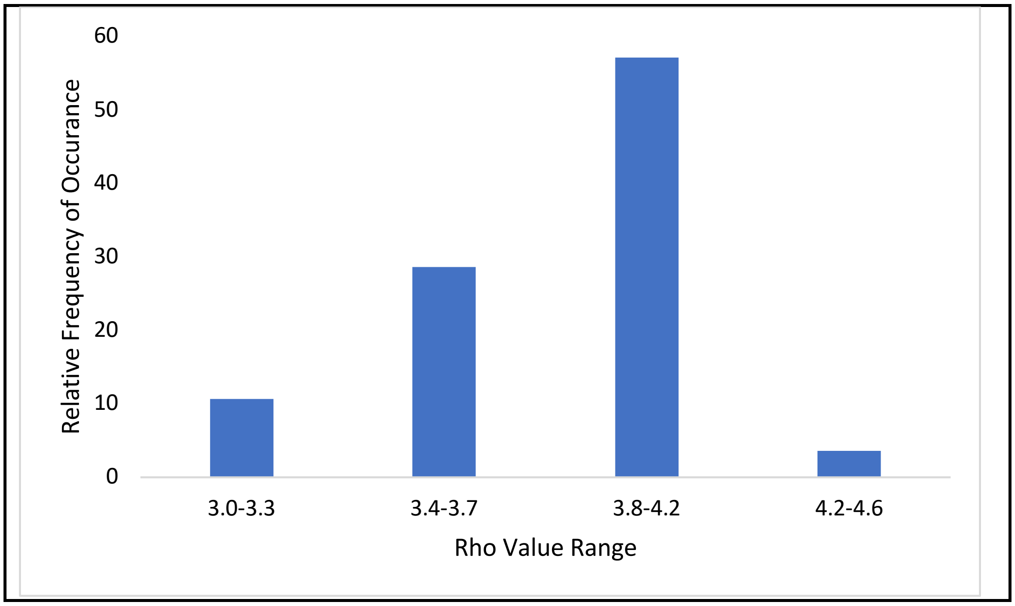

Figure 2: Rho Value Frequency.
57.1% of electrodes demonstrate ideal rho values in the range of 3.8 to 4.2. Rho values exceeding 4.2 account for 3.57% of electrodes, while rho values between 3.4-3.7 and 3.0-3.3 account for 28.6% and 10.7% of electrodes accordingly. (n=28)

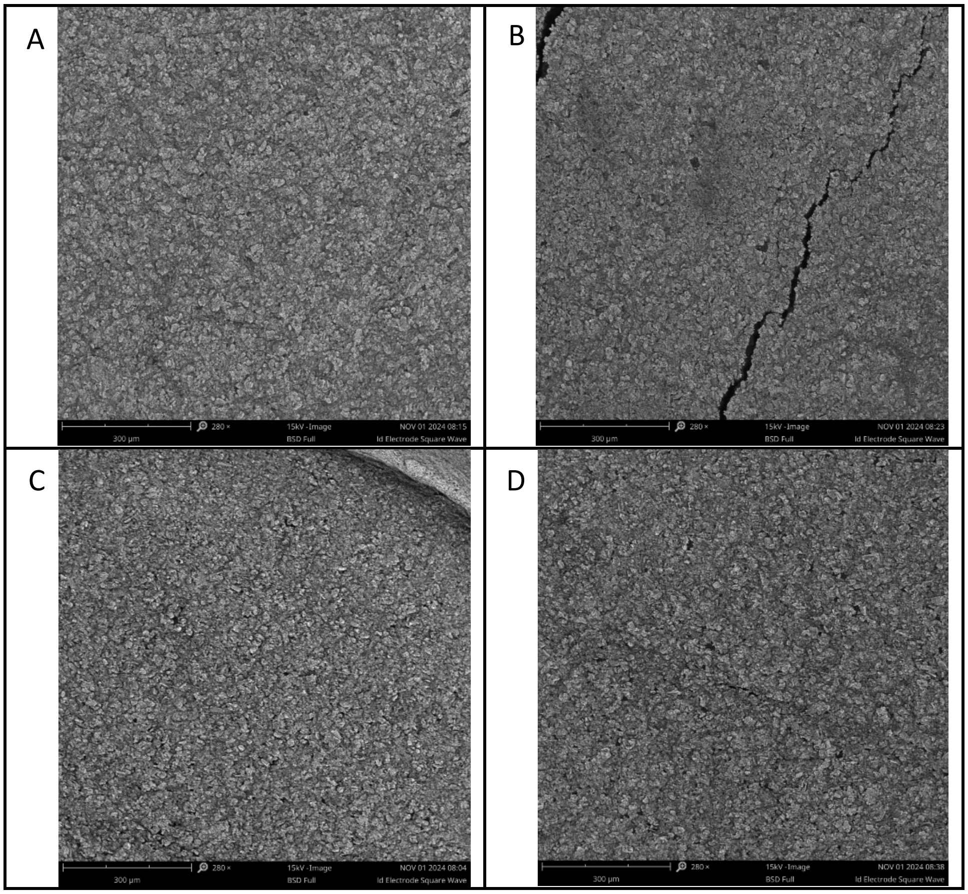

Figure 3: 280x Magnification Scanning Electron Microscope Images. Electrodes were coated with gold on 9/14/2024 (A), 9/16/2024 (B), 9/23/2024 (C), and 10/21/2024 (D). Each image shows gold thoroughly covering the carbon electrode surface. Electrode B shows a crack where some gold did not deposit.

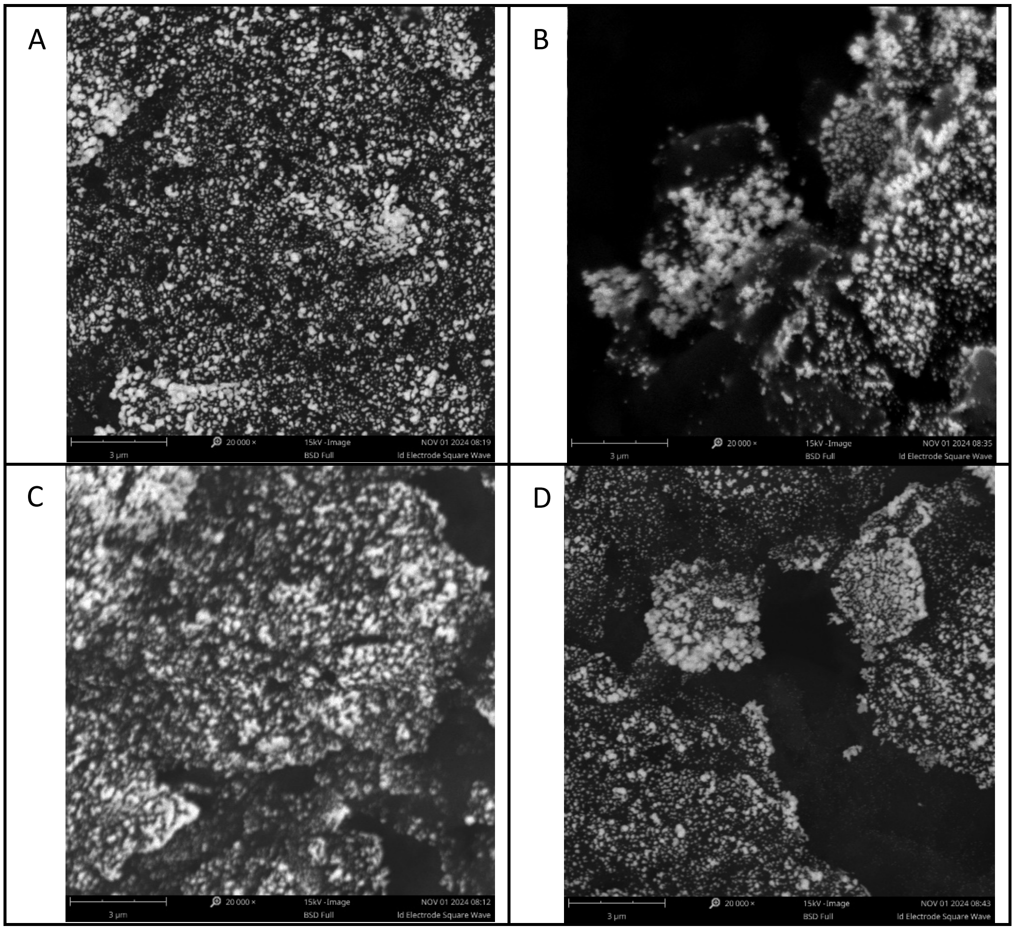

Figure 4: 20,000x Magnification Scanning Electron Microscope Images. Electrodes were coated with gold on 9/14/2024 (A), 9/16/2024 (B), 9/23/2024 (C), and 10/21/2024 (D). Spherical nanostructures shown are buds. No dendrites are present. Some buds are beginning to develop points, but this does not change classification from bud to dendrite.

During the timeframe of the scholarship, I plan to investigate methodology for completing biosensor fabrication. The next step is to optimize alkane thiol modification of the gold surface. Methods for this process have already been developed but will need to be modified for the chip-based sensor. I will research the conditions required for the attachment of the alkane thiol to optimize the production efficiency of ECL nucleic acid-based biosensors.

References:

Yang, W.; Gerasimov, J. Y.; Lai, R. Y. Folding-based electrochemical DNA sensor fabricated on a gold-plated screen-printed carbon electrode. *Chemical Communications* **2009**, No. 20, 2902. https://doi.org/10.1039/b904550c.

5. **Presentation of research results (past and future conferences, publications, seminars, etc.)**

Wegner, Andrew J., Conda-Sheridan, Martin. Effects of pH on Peptide Amphiphile Aggregation. Oral Presentation given on August 7, 2023 at the 2023 INBRE Conference at Lied Lodge, Nebraska City, NE.

Wegner, Andrew J., Conda-Sheridan, Martin. Effects of pH on Peptide Amphiphile Aggregation. Oral Presentation given on April 19, 2024 at the Nebraska Academy of Sciences Conference at Nebraska Wesleyan University, Lincoln, NE.

Wegner, Andrew J., Gross, E.M. Optimization of Au-plating and Modification of Carbon Ink Stencil-Printed Electrodes. Poster presentation given on June 18, 2024 at the National IDeA Symposium of Biomedical Research Excellence in Washington District of Columbia, WV.

Wegner, Andrew J., Gross, E.M. Optimization of Au-plating and Modification of Carbon Ink Stencil-Printed Electrodes. Poster presentation given on August 5, 2024 at the 2024 INBRE Conference at Lied Lodge, Nebraska City, NE.

Wegner, Andrew J., Gross, E.M. Optimization of Au-plating and Modification of Carbon Ink Stencil-Printed Electrodes, Poster presentation given on October 13, 2024 at the American Chemical Society Midwest Regional Conference at Creighton University, Omaha, NE.

Future Presentations:

Wegner, Andrew J., Gross, E.M. Optimization of Au-plating and Modification of Carbon Ink Stencil-Printed Electrodes. Poster presentation given at Creighton Honors Presentation Day at Creighton University, Omaha, NE.

Wegner, Andrew J., Gross, E.M. Optimization of Au-plating and Modification of Carbon Ink Stencil-printed Electrodes. Oral Presentation given at the Nebraska Academy of Sciences Conference at Nebraska Wesleyan University, Lincoln, NE.

6. **Post-graduate plans (job market, graduate school, medical school, etc.)**

I plan to work in industry for a year before attending graduate school in pursuit of a Ph.D. in Materials Science.

7. **Number of semesters involved in research, including current semester (summers count as two semesters)**

13 semesters

8. **Anticipated graduation date**

May 17th, 2025