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Development of Nanostructure based Corrosion-Barrier Coatings on Steel for Transmutation Applications: Quaterly Report

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Project Title : Development of Nanostructure based Corrosion-Barrier Coatings on Steel for Transmutation Applications

Quarterly Report

During the past quarter, this project employed one graduate student (Pavan Singaraju) and two undergraduate student researchers (Michael Sadowitz and Jonathon Ross) and made the following accomplishments :

- Acquisition of steel samples for experiments
- Design and fabrication of specialized anodization apparatus to accommodate steel samples
- Investigation of adhesiveness of aluminum on steel
- Investigation of effects of anodizing acids on steel to identify most appropriate acid and a suitable barrier material

Acquisition of steel samples for experiments

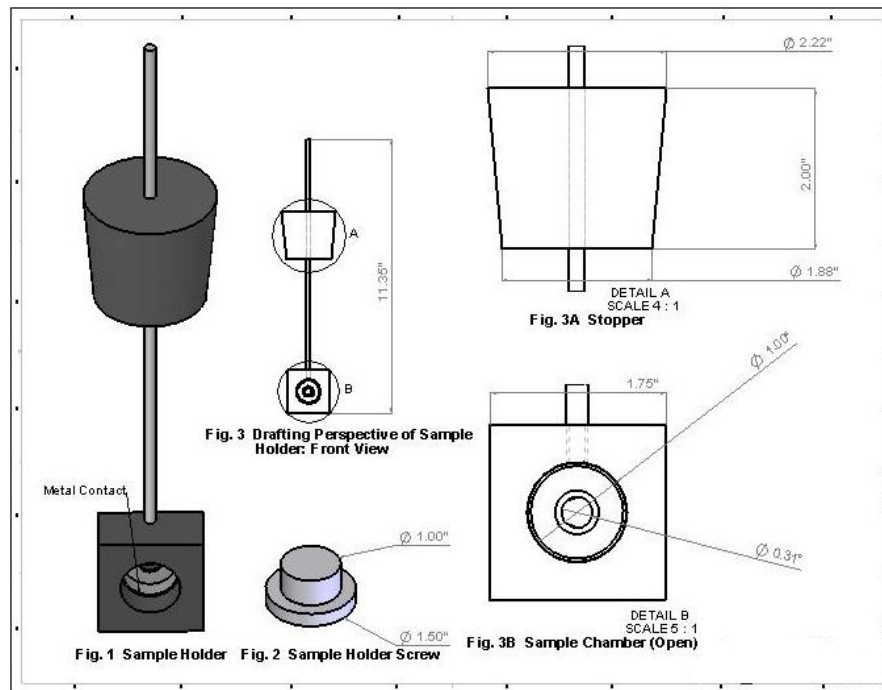
Four HT-9 Martensitic steel samples were obtained from our collaborator at LANL (shown on right). The average dimensions of the samples are $1\frac{1}{4}$ inches in length, $\frac{5}{16}$ inches in width and $\frac{1}{32}$ inches in thickness. Based on the shape of the sample, it was decided that it will be the most beneficial to use square pieces for experiments, which will provide approximately four experimental samples from each steel sample.



Design and fabrication of specialized anodization apparatus

A specialized anodization apparatus was designed and fabricated to accommodate the particular shape and thickness of the steel samples. The schematic diagram of the sample holder is shown in Fig.1. The apparatus consists of three main parts: the stopper (shown in Fig. 3A), the sample chamber (shown in Fig. 3B), and the threaded rod (threads not shown) running through the stopper and the sample chamber. The square portion of the sample chamber, the stopper, and the sample holder threaded screw (threads not shown) are made of Teflon. A metal contact, labeled in Fig. 1, is placed inside the sample chamber. The rod is a continuous piece of metal that touches this metal contact (see Fig. 3B). An acid-resistant stopper is placed inside the chamber to prevent solution from leaking in. The sample is then placed inside the chamber. A metal backing is placed on top of the sample, followed by a round contact whose diameter is equivalent to the inner diameter of the metal contact with a spring attached. The sample holder screw is fastened securely; this entire procedure both prevents solution from leaking in and creates a contact so voltage/current readings can be taken on the sample. The sample holder is the anode. The sample holder is then placed inside a specially designed container and

immersed in the acidic solution. The stopper prevents the sample holder from falling into the apparatus.



Schematic layout of the sample holder for anodization of aluminum coated steel samples.

Investigation of adhesiveness of aluminum on steel

An extensive literature search was carried out to investigate the adhesiveness of aluminum on steel; however no data was available in this field. It was decided that the adhesiveness of aluminum on steel will be determined experimentally using scratch tests, and one of the test samples will be dedicated for this purpose. The need for any barrier metal will be determined based on the scratch tests.

Investigation of the Effects of anodizing acids on steel

Anodization of aluminum is carried out in either sulfuric, phosphoric or oxalic acids. However, it is well known that acidic environments corrode steel; the rate of corrosion depends on factors such as the pH and the temperature. The results are briefly summarized below.

Sulfuric acid: The corrosion rates of different grades of steels as a function of temperature and concentration were studied [1]. It was noted that the austenitic grade steels, especially the molybdenum grades, have significant resistance at low concentrations and temperatures. In stainless steels, increase of chromium content increases the corrosion rate in sulfuric acid [2]. But addition of nickel, molybdenum and

copper increases the corrosion resistance. An important observation is that austenitic steels do not get corroded in very high pure sulfuric acids [3].

Phosphoric acid: The corrosion rates of different steel substrates in pure phosphoric acid solutions at higher temperatures were obtained from the literature [1]. Some of its alloys like G-30 and 28 exhibit high anti corrosion resistance. But in industry, the acid encountered is not highly pure and contains several contaminants that affect the corrosion rate. The presence of chlorides and fluorides increase the rate of corrosion, but magnesium reduces it [4].

Oxalic acid: The corrosion rate of steel in oxalic acid was found to be much less compared to the other acids at room temperature [6]. However, if the temperature is increased to 50 C, the corrosion rate triples for the same concentration of oxalic acid.

Based on the above investigation, it was decided that oxalic acid will be used to carry out the anodization of aluminum on steel.

With the research group functioning well, and with completion of the above tasks, the project is now ready for the next step of aluminum deposition and anodization, which will be carried out during the next few months.

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