Appalachian Transportation Institute (ATI) Research Project Description

Project Number: ATI TRP 99-05-2
Project Title: Use of Electro luminescence Technology for Highway Signage- Phase II Demonstration Highway Sign

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Project Objective: The objective is to design, build and test a highway sign utilizes electro luminescent technology, which that enables highway signs to be more visible during inclement weather at lower energy costs.

Abstract: Laboratory work will be combined with reviews of highway signage protocols, requirements and potential applications that will lead to prototype design requirements for a typical highway sign that should have the potential to improve safety for the motoring public and produce energy savings for the transportation industry. The prototype design will be prepared in anticipation of accelerated environmental exposure experiments and that will also address legibility criteria under various inclement weather scenarios. Upon completion the highway sign will be placed along a highway in West Virginia including sensor instrumentation for inclement weather monitoring and evaluated for weather sustaining availability over the winter season.

Task Descriptions:

1. Evaluate current encapsulated product

The utility of applying 7 forms of microscopic analysis will be evaluated using one lamp selected by MRE microscopically in a preliminary analysis to define the current, state of the art of the product. These 7 methods are defined below:

1 Laser Scanning Confocal Microscopy (LSCM). This 3-Dimensional imaging method is capable of imaging within transparent media. The applicability

of imaging lamp fluorescence intensity as a function of subsurface position will be investigated. The ability of this technique to yield relative particle emission efficiencies will be determined.

2 Micro-electro luminescence spectroscopy (MES). This is a technique, which is capable of determining the relative efficiency of visible electro luminescence as a function of surface location, within spectral windows 20 nm wide within the range 450 - 650 nm. Shifts in emission intensity or wavelength are often indicative of impurities.

3 Micro-photoluminescence spectroscopy (MPS). This is a technique, which is capable of determining the relative efficiency of ultraviolet induced visible photoluminescence as a function of surface location, within spectral windows 20 nm wide within the range 450 - 650 nm. Shifts in emission intensities or wavelength are often indicative of impurities.

4 Scanning Electron Microscopy: Secondary Electron Imaging (SEM:SEI) The morphology of the sample surface (including pitting, cracking and corrosion) can be imaged using SEI.

5 Scanning Electron Microscopy: Cathodoluminescence Imaging (SEM: CI) This mode utilizes the relative intensity of the electron beam excited light to produce the image.   The morphology of the sample surface obtained via SEM:SEI may be correlated with the local lamp efficiency. Environmentally unprotected regions(including pits, cracks, and corroded regions) can be expected to display diminished intensity in CI images. These regions will be further investigated for using chemical imaging method described below (EDAX).

6 Scanning Electron Microscopy: Energy Dispersive X-ray Analysis (SEM:EDAX) This is a method of chemical imaging which can determine major elemental components of imaged particles. Migration of materials during a corrosion process can be monitored using this method. This will be of interest particularly for substrate components migrating into the phosphor layer. This is a relatively surface sensitive technique, and may require cross sectioning of the lamps to provide access to corrosion sites. Alternatively, pinholes, cracks, or pits will also disclose sub layers for elemental analysis.

7 Scanning Electron Microscopy: Voltage Contrast Imaging (SEM: VCI) The electrical connectivity of the transparent top electrode, or other electrical connections can be imaged using VCI. VCI provides a means of imaging portions of the surface of a sample, which are electrically connected, to a junction formed to the surface. The application of this method to the study of bottom electrode connectivity will be evaluated. Electrical connectivity should be correlated with MES, and should explain differences between MES and MPS images.

2. Enumerate/prioritize current environmental mechanisms of failure

Selected areas of between 4 and 6 sample lamps which have been subjected to preliminary environmental challenges either by MRE or by the Norton Group, will be studied microscopically using a subset of the methods described above, in a preliminary analysis to define the types, mechanisms and relative importance of environmentally related failure mechanisms. Optimizing product lifetime will require identification and mitigation of the most important failure mechanisms.

3. Perform literature review of alternative encapsulation (chemical passivation) methods

A document listing and summarizing current practice in environmentally isolating electronic components will be assembled. The two most promising methods will be described in detail.

4. Define and Design Accelerated Environmental Testing Protocol

The most cost effective methods of performing environmental testing will be determined. The definition of accelerated testing methods to be used in the development cycles of the product will be based upon experience of MRE, experience gained by the Norton group during the performance of subtask 1, and through discussions with the Accelerated Pavement Testing Facility Group from Ohio University. Potential conditions, which could be included within the domain of environmental challenges, will be thermal cycling, extremes in humidity, and extremes in operating power.

5. Specify Prototype Encapsulation Alternative(s) for Fabrication

One to two modifications to the current encapsulation method will be specified, if modifications are found to be necessary. These specifications will be based upon findings obtained during the performance of subtask 3. Implementation of the recommendation(s) by MRE to produce prototypes will result from mutual agreements obtained during cost/benefit discussions.

6. Test Prototype(s)

Between 1 and 6 sets of lamps (two matched lamps per set) prepared as prototypes using methods recommended in subtask 5 will be tested (as defined during the performance of subtask 1) before and after accelerated environmental testing (as defined during the performance of subtasks 4.). This may represent three developmental cycles of two distinct prototypes, or 6 developmental cycles of a prototypical device.

7. Perform Analysis of Prototype Test Results

A summary document will be prepared including a comparative analysis of microscopic characteristics of the prototypes before and after accelerated environmental challenges.
The extent of remediation of environmental sensitivities disclosed during initial investigations (i.e. during the performance of Subtask 1) through the adoption of enhanced fabrication protocols will be documented. Remaining sensitivities, and any new environmental sensitivities identified during the performance of Subtask 6, with suggestions for remediation, will also be documented. It is understood that the devices will have a limited lifetime, and that the objective of this effort is to identify the environmentally related failure mechanisms, and to passivate the device against these mechanisms in the most cost effective manner.

Milestones, Dates, Schedule: Start Date: 03/15/00 End Date:08/31/01

Budget:

Year 1	$150,000
Year 2	$305,000
Total	$455,000

Student Involvement: The project will provide employment support for at least 1 undergraduate and 1 graduate student. The student workers will support the Principal Investigator as project assistants. This project is anticipated to lead to at least one Masters thesis in Chemistry.

Relationship to Other Research Projects: None at this time.

Technology Transfer Activities: Final reports will be available on the ATI website. All, ATI Principal Investigators will present findings through the ATI Transportation Seminar Series to invited guests from WVDOT, USDOT, other ATI Principal Investigators, students and other invited guests. Other opportunities to present the project results will be explored including conferences and peer reviewed journals, etc.

Potential Benefits of this Project: This technology may improve legibility and visibility of typical highway signs under fog conditions as well as possibly reduce or eliminate frost and dew formation. Improved highway safety may also result from this study.

TRB Keywords: Highway signage, highway safety