NEVADA DEPRTMENT OF TRANSPORTATION
RESEARCH PROBLEM STATEMENT

Expert Task Group (ETG) on "Better Design of Roads and Bridges"

I. PROBLEM TITLE:

Evaluation and Improvement of the Effectiveness of Various Pavement Striping Materials using a Multi-Technique Physico-Chemical Testing Approach

II. PROBLEM DESCRIPTION

There are numerous factors affecting current road marking materials and those include material's degradation under long-term exposure to sunlight, heat, water, traffic conditions etc. The research proposed in this project will evaluate strategies to increase the usable lifespan of pavement striping materials in Nevada, by assessing new and improved materials compositions under extended exposure to elevated temperatures and irradiation-related effects such as generated by long-time exposure to sunlight and heavy traffic conditions. It is indispensable to determine the physico-chemical characteristics of currently used striping compositions, understand the underlying reasons of their degradation identify and the likely benefits of improving on specific compositions. The proposed microstructural approach involving physico-chemical testing based on laser and thermal techniques is a unique approach in studies of pavement striping materials.

III. OBJECTIVES

The objective of this project is to understand how the microstructure of striping materials is affected by environmental stresses and relate these factors to how such materials could be improved (by modifications of composition, fabrication, post-fabrication treatments) and made more lasting.

In this project, we propose to lay out a systematic plan to address microstructural properties of pavement striping materials, including: macro-structure and micro-structure, chemistry and the spatial distribution of chemical components (Figure 1), especially in relation to exposure to environmental degradation (rain, sunlight, heat) as well as thermo-gravimetric properties that describe the response of materials to elevated temperatures. The primary objectives of this research are to:

- Perform comparative studies of the chemical compositions and micro-structure of several different striping materials, at different stages of their life
- Perform comparative studies of thermal characteristics of several different striping materials, at different stages of their life
- Correlate compositional differences with thermal properties and structural integrity
- Correlate micro-structural differences with material lifespan in practical applications
- Propose improvement to material compositions in view of extending their structural stability and lifetime

The overall goal is indicate what improvements can be made to currently used pavement striping materials in order to extend their structural stability and hence usable lifespan and related costs.

IV. CURRENT PRACTICE and RELATED RESEARCH

Road striping materials can be divided into several categories with varying usable lifespan:

- *Paint*, sometimes with additives such as retroreflective glass beads. It is composed of pigments, resins or binders, and water or solvents plus UV stabilizers and fillers. Lasts 9 to 36 months. Here we could leverage our long-time expertise in glass research in relation to the additive glass beads with retroreflective function.
- *Thermoplastic binder* systems are based on one of three core chemistries: hydrocarbons, rosin esters or maleic modified rosin esters (MMRE). Thermoplastic coatings are homogeneous dry mixes of binder resins, plasticizers, glass beads, pigments, and fillers, and provide good balance between cost and performance longevity, lasting 3 to 6 years.
- *Preformed thermoplastic* pavement markings; are applied on the road surface with a heater to 200°C before application with a propane heat torch, and they last 3 to 6 years.

The different chemistries of the above materials and the mixture of different components are directly related to their endurance to the elements over time.

V. RESEARCH METHODOLOGY

This research seeks improvements to the compositions of road striping materials through the understanding of their physico-chemical micro-structural characteristics and their influence on their aging. The following tasks are proposed to conduct the micro-structural studies. *Task 1.* Study pristine striping materials, classified from least to most performant; characterize them from a microstructural point of view; propose improvements based on results. *Task 2.* Study aged material samples from actual NV roads and compare them with pristine materials to understand the microstructural signatures of the degradation/aging process; *Task 3.* Examine the interaction between paint, epoxy or plastic on one hand and glass beads on the other hand, and its effects on the structural integrity of the material as a whole.

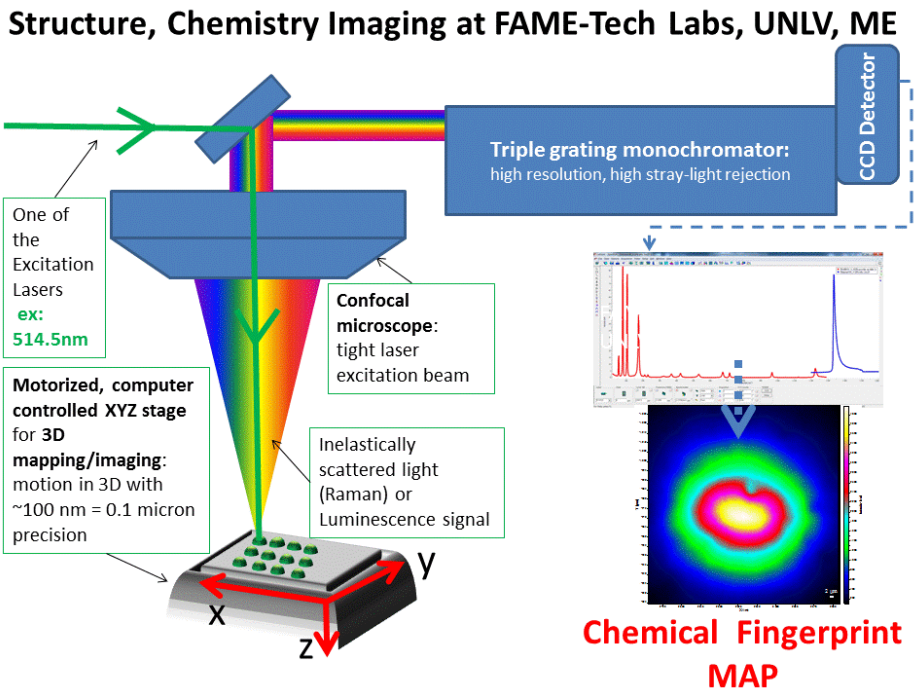

Figure 1. Sketch illustrating the experimental setup for laser spectroscopy or "chemical fingerprinting": Raman and luminescence spectroscopy, and which allows to obtain 2D images of chemical composition distribution in a pristine striping material or in one after exposure to environmental stresses.

Overview of Micro-Structural Studies: The macroscopic properties and performance of striping materials for pavements (thermal stability, resilience to chemical attack and exposure to radiation form the sun etc.) are entirely conditioned by their inherent properties on the micro- and nano-scale. Therefore knowledge of the material's microstructural characteristic will pave the way to improvement of its macroscopic properties and overall performance in real world applications.

A *multi-technique materials characterization* study on the micro- and nanoscale will be carried out to link the materials chemistry and microstructure to its macroscopic performance. Micro- and nanoscale materials characterization will allow us to elucidate: (i) thermal properties such as kinetics of heat-induced chemical reactions using differential scanning calorimetry; (ii) elevated temperature-driven sample mass changes (decomposition, oxidation) using thermogravimetry; (ii) chemical composition evolution/new product formation and molecular level structural modifications (nucleation and growth of new phases) using high-resolution laser spectroscopy (Figure 1), (iii) overall texture modification using optical stereomicroscopy.

VI. IMPLEMENTATION POTENTIAL

The recommendations suggested by this study can be used immediately to specify which materials and products for traffic strapping/markings will last longer. The proposed research has the potential to provide new compositions for improved striping materials and thus reduce current maintenance costs of replacing traffic markings.

VII. URGENCY AND PAYOFF POTENTIAL

The proposed research will provide NDOT use of improved current marking materials and thus reducing maintenance costs of replacing traffic markings. The potential maintenance cost and safety savings are significant. Many times, traffic accidents are associated to poor or unclear stripping.

VIII. ESTIMATED BUDGET

The estimated budget is $200k including: professional salaries (PI, Co-PI and a graduate student); Student tuition fees; Purchase of materials and lab supplies; Travel; and Overhead (23% Excluding Student Tuition and Fees).

IX. DATE AND SUBMITTED BY

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