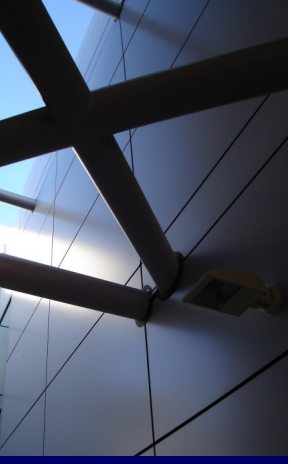

MECHANICAL ENGINEERING

The Department of Mechanical Engineering presents:

The Master's Dissertation Defense of:

Jon Redenius

Wednesday, March 18, 2015
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Femtosecond laser-induced oxide formation on molybdenum thin films in varying oxygen environments

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Dr. Guillermo Aguilar, Chairperson

Pulsed laser processing is a technique to induce optical and structural changes in materials, such as oxide line and ring structures, when metallic samples are irradiated with high repetition rate lasers in oxygen and mixed atmospheres. A study of femtosecond laser processing on thin films of the transition metal molybdenum in air and oxygen is presented. The molybdenum oxides, which can have very different electrical and optical properties, are gaining momentum in novel technical applications such as electrochromic devices, electrodes in microbatteries and solar cells, gas sensors, and catalysts, among others.

These latest short-pulsed, ultrafast lasers have only recently begun to find more widespread uses in research institutions. The novelty of the femtosecond lasers is that the pulse width is shorter than the electron cooling time, requiring advanced physical models to couple the electron and lattice heating. Because of this, femtosecond lasers have found advancement in the fields of physics, chemistry, engineering, medicine, and material science. When a femtosecond laser irradiates a transition metal thin film, the thin film reacts with the gaseous species producing different chemical and structural phases. These oxides and phases are dependent on the localized atmosphere and laser irradiance characteristics, e.g. the fluence, polarization, pressure, and duration of exposure.

The aim of this thesis is to determine the correlation between all the different tunable variables and the respective oxides formed on the thin film when irradiated by a femtosecond laser, both in ambient air and in varying pressurized oxygen atmospheres. The inputs varied in this study are the following: laser fluence/output power, irradiation time, gas, and gas pressure. Raman spectroscopy, atomic force microscopy, profilometry, and scanning electron microscopy are used in characterizing the oxidation and phase shifting. It is shown that, with the addition of a pure (>99.9%) oxygen gaseous environment, the resulting molybdenum trioxide (MoO3) area is both much larger (~50%) and oxidized with much lower fluences and timescales than the corresponding laser irradiations done in ambient air environments. Small variances in oxygen pressure show small but present increases in trioxide formation as the pressure is slightly increased. Changes in the other different oxides formed (MoO2 and Mo4O11) are also reported based on gas and pressure changes.