## Introduction

The Queen's University Experiment in Liquid Diffusion, QUELD, is one of a series of investigations of liquid diffusion in microgravity, conducted by the Queen's University Department of Materials and Metallurgical Engineering in conjunction with the Canadian Space Agency and NASA.

The intent of these experiments was to further the understanding of the behaviour of liquid metals, as diffusion coefficients determined in terrestrial experiments have proven to be irreproducible. By determining the diffusion coefficient of a binary alloy in microgravity and comparing it to data from ground-based tests, it is possible to detect the degree to which convection causes deviation of experimental results from theoretical predictions.

The first QUELD experiments, CANEX II, were conducted in September 1992 aboard the U.S. Space Shuttle Columbia. In these, four binary alloy systems were analysed: Pb-Au, Pb-Ag, Bi-Ag and Bi-Mn. QUELD Increment 2 sent 37 diffusion couples in Pb-Au, Pb-Ag, Sn-Au, Sn-Ag, Al-Cu, Al-Ni, and Al-Si to the Russian Space Station MIR. Corresponding terrestrial runs were also performed. In all cases, the prepared diffusion couples were contained in graphite crucibles within sealed metallic tubes, and were processed in an apparatus developed by Queen's University specifically for these experiments. The design of both the sample tubes and the QUELD furnace are discussed more extensively later in this paper, but it should be noted now that isothermal conditions must be maintained at all times along the length of the diffusion couple in order for the results obtained from it to be meaningful.

Unfortunately, it would seem that some difficulties encountered during processing on MIR may have led to a non-isothermal condition in several sample tubes. The astronaut performing the experiments noted that several of the tubes were not fully inserted into the furnace while they were being heated. There is concern that some work performed on the furnace apparently bent one of the arms which hold the sample tubes and move them within the device. Therefore, tubes were entering the furnace itself at an angle, and were catching on the walls before full insertion was achieved. In addition, there was a great deal of interest about a number of questionable thermocouple readings which might indicate a temperature gradient or other processing problems.

It was therefore determined that an analysis of evidence on the protective tubes would be beneficial, as it could help confirm whether a sample was processed under the desired conditions. More specifically, it was hoped that the oxide film on the tubes would provide specific information about the furnace temperature, the treatment time, and the degree of container insertion into the furnace.

An understanding of appropriate high-temperature oxidation theories provides a link between processing and oxide thickness. Simple physics – the principle of visible light interference tints -- may then be used to form the basis of an analysis, since oxide colour can be shown to be a function of its thickness.