

KSC Corporate S&MA Project Status Report FY 2009 Project Review

Task

Defect Depth Measurement Using White Light Interferometry

Center Point of Contact

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Objective

The objectives of the White Light Interferometry project are the following:

- * Demonstrate a small hand-held instrument capable of performing inspections of identified defects on Orbiter outer pane window surfaces.
- * Build and field-test a prototype device using miniaturized optical components.
- * Modify the instrument based on field testing and begin the conversion of the unit to become a certified shop-aid.

Background

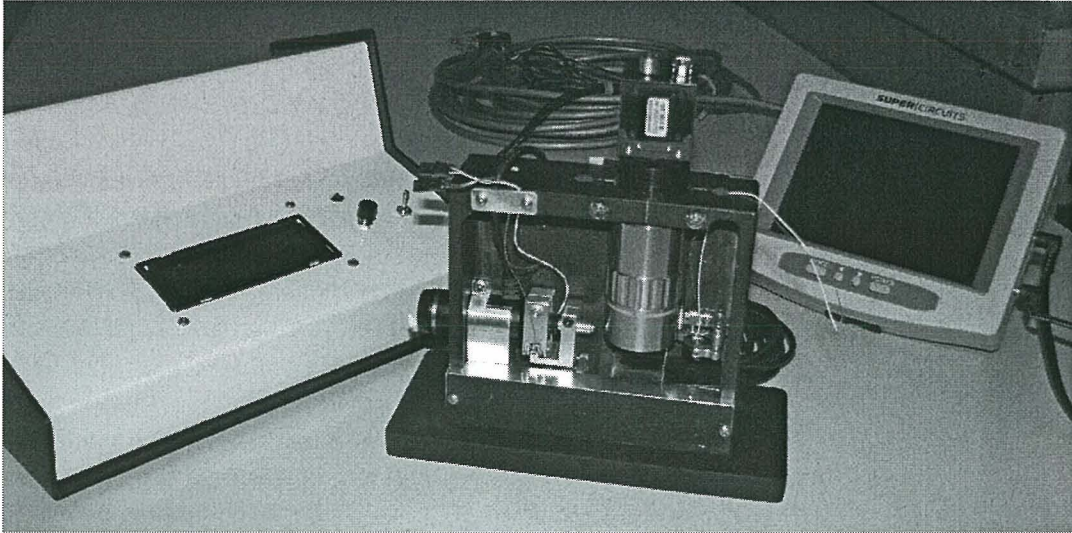
The Orbiter windows are damaged both by micro-meteor impacts and by handling and require careful inspection before they can be reused. The launch commit criteria requires that no defect be deeper than a critical depth (this value changes from window to window depending on location, but typically it is about 0.001 inches). Up until a few years ago the Shuttle program was using a refocus microscope to perform a quick pass/fail determination and would then use mold impressions to better quantify any defect that failed. But, the refocus microscope was not reliable and a new quick measurement device was sought. A portable white light measurement system was suggested and funded by the NNWG to meet this need.

Over the same period within our lab, the Shuttle program funded the development of a portable, handheld, optical, window inspection device (PHOWID) to eventually replace the mold impression process. So at the start of this project the plan was for a white light inspection system to eventually replace the refocus microscope as a quick defect depth check and then to replace the mold impression process with the PHOWID to provide more quantitative defect measurements.

Approach

An imaging white light interferometer was developed that demonstrated more than enough capability to replace the refocus microscope. This device operates by launching broadband (i.e. white) light into a Michelson interferometer and then moving a reference mirror back and forth to match up with the distance to the Orbiter window surface. Interference fringes only appear when these two distances match, so as the reference mirror is moved the appearance of fringes on the imaging system correspond to the location of reflection sites on the window.

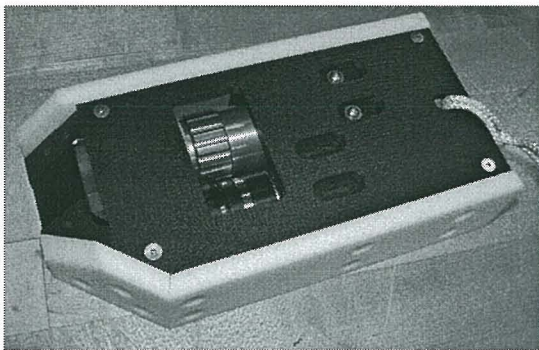
The image below shows the final version of the white light defect inspection device. The actual interferometer is in the center of the picture and is composed of a microscope (camera on microscope objective), an interferometer (packaged into the base region and not apparent), and a scanning mirror with position readout (the small motor and wired assembly to the left). The console in the left of the picture is a control unit and the display used is shown to the right.



Benefits/Payoff/Products

As the white light device was being developed, Shuttle window inspection requirements changed affecting the needs of the program. Essentially, the launch commit criteria for a defect depth was made larger, making it easier to find and evaluate defects.

Consequently, the Shuttle program decided that a handheld dual imaging system could provide an adequate quick defect evaluation and that PHOWID could do the detailed defect measurements. So a handheld camera system was constructed consisting of a dual sighted wide field of view camera (for locating the defects) and a microscope (for evaluation of the defects). The microscope included a refocus feature allowing the operator to focus on the defect providing some insight into its depth. The pictures below show the prototype version of this dual camera and the ground support equipment (GSE) version of the PHOWID.



Consequently, it was decided not to field the white light defect measurement device, but there were still products achieved from this work. While developing this instrument three novel concepts emerged, an inductive position sensor, a white light absolute distance sensor, and a novel technique for calibrating spectrometers. All three, as well as the white light defect measurement device itself, were submitted as new technology reports and sent through the technology transfer office. Two of these concepts, the inductive position sensor and the spectrometer calibration process, have received interest from commercial entities and patent applications are being considered.

Status/Recent Accomplishments

The NNWG portion of this project ended on September 30, 2009, but with follow on funding from Shuttle the final version of the dual camera system is being constructed and will hopefully be delivered before the end of the calendar year as a shop aid. The PHOWID is moving through the GSE conversion process and should be a field item in the near future. Commercialization on the concepts mentioned above is ongoing.