Characterisation of New Planar Radiometric Detectors using Carbon Nanotube Absorbers under Development at NIST

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Carbon nanotube technology, in conjunction with silicon micro-fabrication techniques, has enabled us to develop planar radiometric detectors, which has led to the establishment of a new generation of primary standards. The goal is to develop compact, fast, and easy-to-use, radiometric calibration systems, spanning the wavelength spectrum from the ultraviolet to the THz region in a single detector, suitable for use with both coherent and incoherent sources, and encompassing open beam and fibre-coupled modes of operation, with utility beyond that of the laboratory environment. Work will be presented comparing scales derived from two new table-top systems, to existing radiant power and optical fibre power scales, traceable to SI.

INTRODUCTION

NIST has initiated a program titled "*NIST on a Chip"* with the intent of establishing chip-scale standards within key, identified areas of research. The standards themselves are compact and portable, and to an extent ubiquitous. In our case this has been implemented by developing next generation cryogenic and room temperature laser power standards, based on three key enabling technologies.

Vertically aligned CNT arrays with near unity absorptivity, grown on silicon substrates, prepared using state-of-the-art micro-machining techniques, and enhanced with a post growth treatment to stabilise the nanotube array. The core technology has been demonstrated by developing cryogenic radiant power meters [1-3], and room temperature radiometers [4] for both terrestrial and space applications (LASP CSIM). These devices are highly efficient, broad spectrum and two dimensional (planar) in nature. See Figures 1 and 2.

The requirements for a planar detector to be accepted by the community as a viable alternative to a 3 dimensional cavity are twofold. It should demonstrate comparable absorptance, but most importantly long term stability. A cavity by design mitigates reflection losses – a 2 dimensional cavity is not afforded that luxury, unless reflective domes are utilised. It is therefore important to ensure and demonstrate the long term reflectance stability of the VACNT forest. Recent work has concentrated on developing a conformal post-deposition coating process to ensure the deposited nanotubes are characterised as being super-hydrophobic. We have instigated a program to monitor the reflectance change of CNT detectors from the ultraviolet to 10.6 µm.

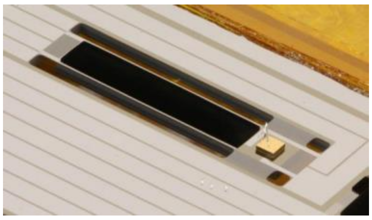

Figure 1.
Photograph of a detector for space applications showing the nanotube forest on a silicon membrane.

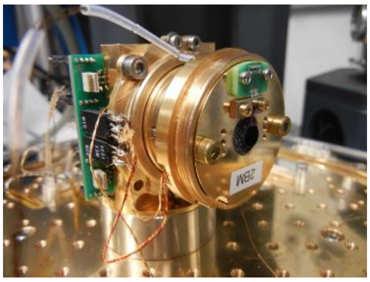

Figure 2. Photograph of a table top mounted cryogenic system showing the black planar detector at the centre. The radiation shields have been removed for clarity. The detector can be used with both open beam and fibre-coupled radiation.

NIST maintains an optical fibre power scale, traceable to SI and disseminated using an electrically calibrated pyroelectric radiometer (ECPR). It is our intention to replace this scale with one derived from our new table-top cryogenic fibre-coupled system, once all characterisation and comparison work is complete. We also maintain spectral power scales on solid-state trap detectors and in the near future we expect to base these scales on our new chip detectors operating in open beam mode in a different, but new, table-top system.

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