§38. Development of a Double Layer Imaging Bolometer Foil

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An InfraRed (IR) imaging Video Bolometer (IRVB) uses a single large (7cm x 9cm), thin (1 – 10 microns) foil mounted in a frame to capture photons and neutrals from the plasma and convert their power to IR radiation which is measured by an IR camera located outside the vacuum vessel through an IR periscope [1,2].

Efforts to improve the sensitivity of the IRVB have resulted in the development of a double layer foil (DLF) consisting of a stainless steel (SS) base layer and a gold absorber layer as shown in Figure 1. The lower heat conductivity of the SS base layer reduces the heat removal from the gold absorber layer and results in a higher temperature and thus a higher sensitivity of the IRVB. A prototype (shown in Figure 2) of the DLF was manufactured in St. Petersburg and tested at NIFS.

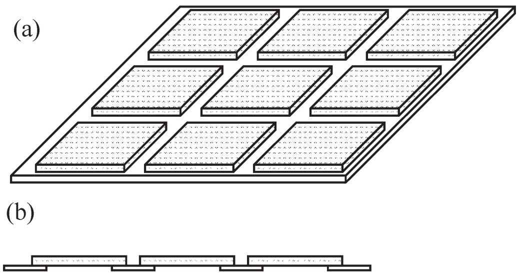

Figure 1. (a) Drawing of double layer foil with SS base (grey) and gold absorber (gold). (b) Cross-section of double layer foil showing perforation in SS under gold absorber.

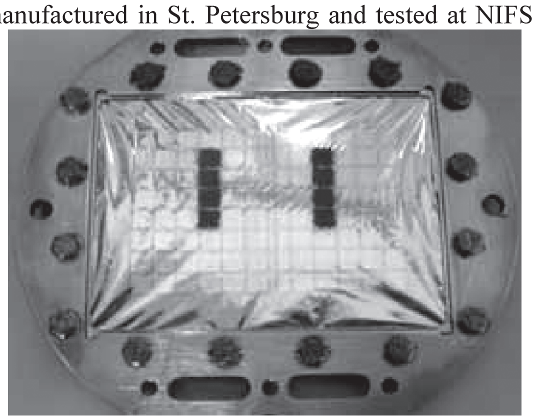

Figure 2. Protoype of a DLF with 2.1 micron and 0.85 micron gold absorbing layers and a 2.5 micron SS base. Some pixels are blackened with graphite to increase the IR emissivity.

This prototype has a SS base layer which is reduced to a thickness of 2.5 microns by electrochemical etching and ion beam etching. The gold layer is then deposited on the SS base by vacuum vapor deposition. In half of the DLF a gold layer of 2.1 microns was deposited and in the other half a layer of 0.85 microns was deposited. Tolerances of gold and SS layers are 0.1 microns. The gold absorber pixel has a dimension of 5 mm x 5 mm and a gap of 1 mm between pixels.

The results of a finite element model (FEM) of the 2.1 micron DLF and a 2.5 micron single layer gold foil were compared with experimentally measured temperatures of both foils when heated by a 15 mW HeNe laser. The evolution of the temperature profile of the DLF from the FEM is shown in Figure 3 along with the measured temperature profile at the final time. Good agreement is seen between the model and the experiment and little cross talk is seen in the adjacent pixels. In Figure 4 the time evolution of the experimentally measured temperature at the center of the DLF pixel is compared with that of the single layer gold foil. This shows the advantage of the DLF in achieving a higher temperature and therefore higher sensitivity.

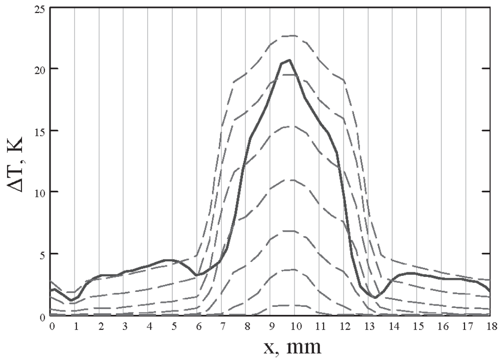

Figure 3. Temperature profile evolution of DLF from FEM (red dashed) at 2.5, 25, 100, 250, 500, 1000, 2500 ms after exposure to laser compared with measured DLF temperature profile at 2500 ms (blue solid).

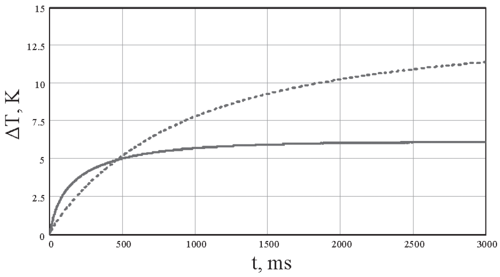

Figure 4. Measured temperature evolution of DLF (dashed) after exposure to laser compared with that of single layer gold foil (solid).

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References

1) Peterson, B.J. : Rev. Sci. Instrum. **71** (2000) 3696.
2) Peterson, B. J et al. : Rev. Sci. Instrum. **74** (2003) 2040.