Patterning of oxide-hardened goldblack by standard photolithography

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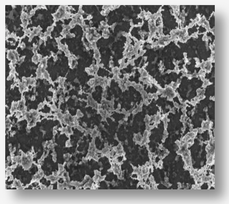
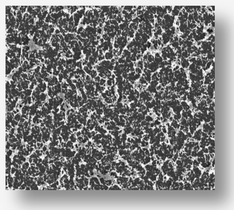
Introduction





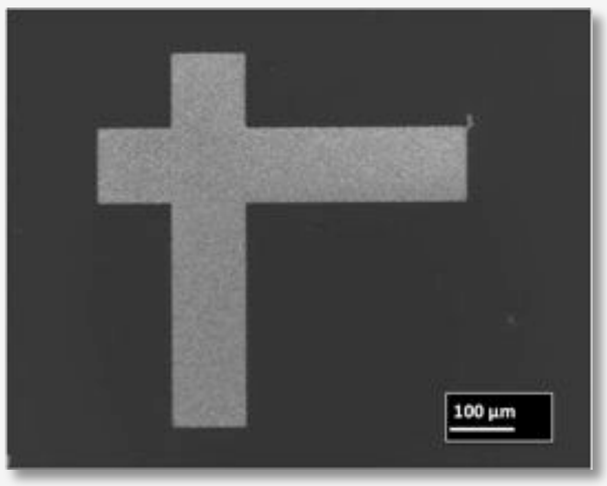
Goldblack has been used for a number of years to improve the spectral absorption of thermal infrared detectors because it has absorption close to unity over a wide bandwidth from visible to far infrared wavelengths

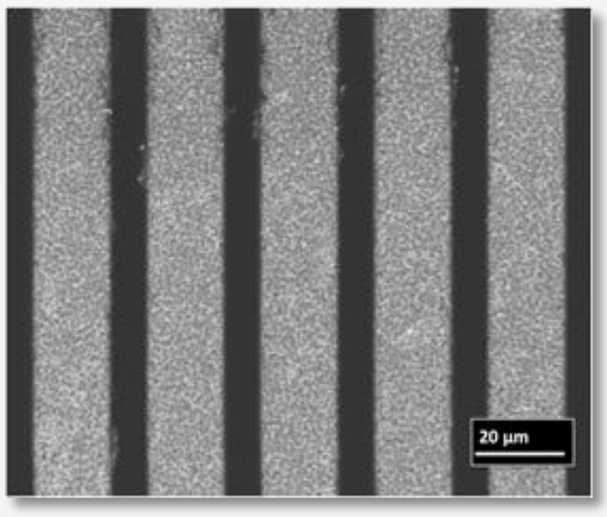
However, Broader commercial application to array detectors has been hampered by gold black's extreme mechanical fragility, which also makes it difficult to pattern.

Objective of the work was to prepare micron size patterns of gold black with high absorption in window of 3-5 µm wavelength. We demonstrated more than 90% of absorption in that window with minimum pattern feature size of 6 µm.

Results

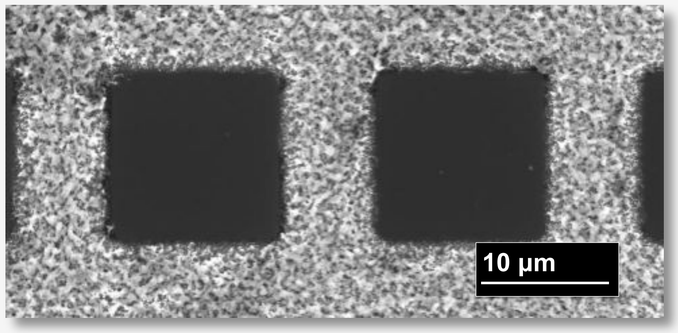
SEM images of example goldblack micro patterns on the silicon substrate is shown. In each SEM image, the gold-black appears light while the substrate appears dark.





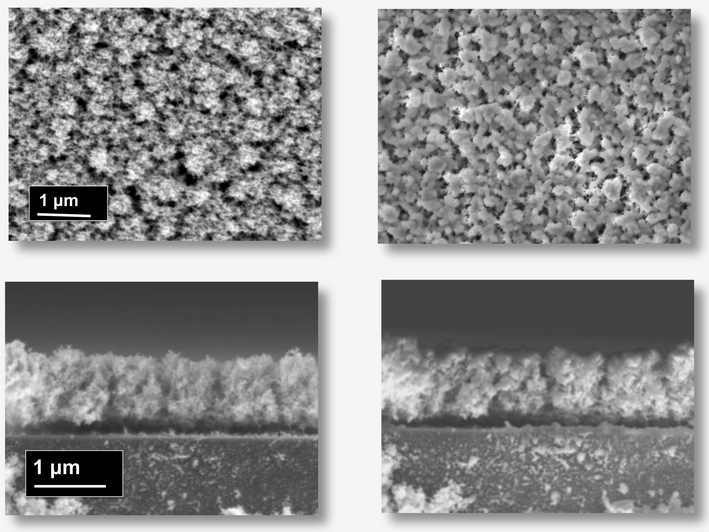
SEM pictures of goldblack micro patterns on silicon substrate

These patterns exhibited high resistance to mechanical damage while maintaining high infrared absorption. The smallest feature size achieved is close to 6 µm as shown.



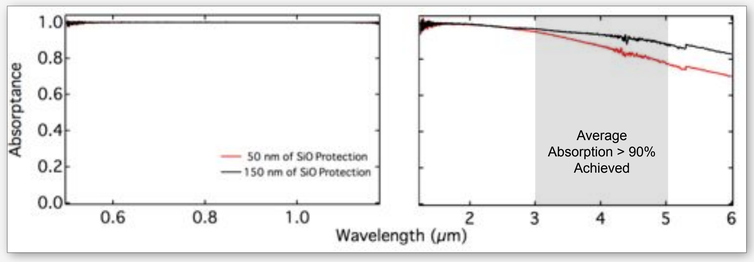
Goldblack pattern with 6 micron feature size

To promote adhesion and to mechanically stabilize goldblack SiO_2 protection layer (150 nm) was deposited on goldblack coatings before wet processes to form patterns. The cross-sectional side views of the goldblack films Suggest that height of the structure remains constant at 3.5 µm even after protection layer deposition on top.



Top view &Cross-sectional side view SEM images of gold black coating before (left) and after (right) protection layer deposition.

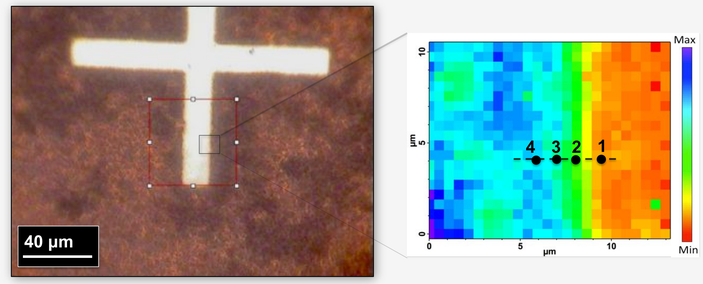
The protection layer does not affect the gold black absorption up to mid-IR either, however wet processes during the pattern formation limit the high absorption up to 7 µm. We still achieve more than 90% of absorption in 3 to 5 µm wavelength window.



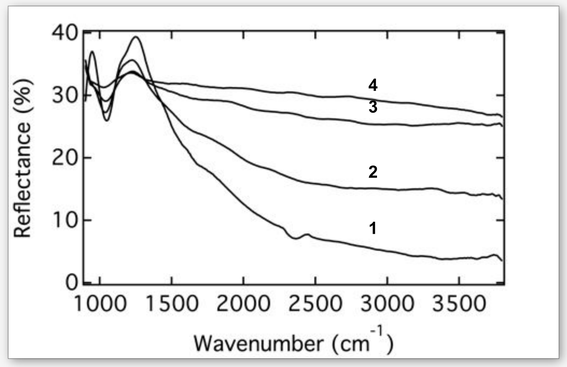
Absorptance spectra of two gold black patterns with different protection layer thicknesses

To study spectral uniformity at higher spatial resolution, goldblack patterns with 150 nm of protection layer were investigated at the UWM Synchrotron Radiation Center with special resolution of 0.54 × 0.54 µm^2.

On the infrared image reflection spectra were extracted from pixels along the line which extends from gold black pattern (red) to silicon substrate (blue). There is a continuous trend of increment in reflection as we move towards the silicon substrate.

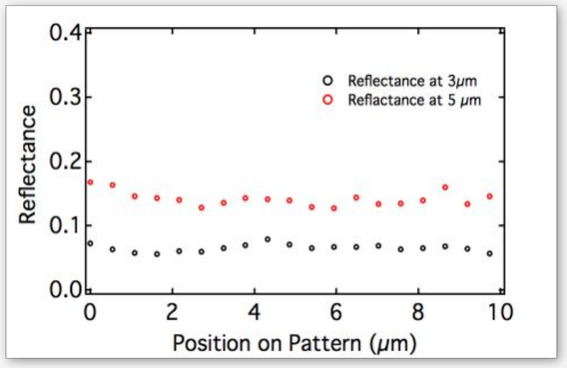


Optical image of goldblack alignment mark on silicon substrate (left) and integrated Infrared image of selected area using IRENI for 3800 to 1700 wavenumbers (right)



Gold Black Patterns on Silicon Substrate

The data on special uniformity of reflectance on goldblack Pattern suggest that at 5 um wavelength reflectance is higher with higher Fluctuations (still low value of 5%).



Spatial variation of Reflectance on goldblack pattern at 3 and 5 µm wavelengths

This work was funded in part by EMX Intl. LLC

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