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# Lossy Metallic Micro/Nano-Structures for Solar Thermal Applications

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Research on controlling heat in photonic devices has been fuelled by their potential application in energy devices, mainly in solar energy[1]–[3]. In this environment thermionic emission is an emerging technology where energy converters turn heat directly into electricity. The basic thermionic solar converter structure is a hot cathode separated from a cooler anode by a vacuum gap. The hot cathode should be a perfect light absorber and a perfect electron emitter in a compact, low cost, planar device. The final objective of our work is to integrate a thermionic solar-energy converted based on polycrystalline diamond as an active material. Diamond thermionic solar converters require substrates with excellent high temperature performance since they have to operate continuously at temperatures around 900 ˚C. Noble metals are an excellent platform for plasmonic applications, however they have a poor performance at high temperatures with melting points close to the working temperature. Therefore our main design requirement for the viability of our integrated device is to work with unconventional metals with higher melting points than noble metals, for example, nickel or molybdenum.

We have already shown that lossy nickel periodic structures are a good candidate to excite plasmons in the visible with high attenuation of the coupled light obtaining broadband absorbers.[4], [5] In this paper we have developed a large area preparation technique based on nanoimprint technology using commercial DVD and CD patterns to create periodic nickel structures. Homogenous samples with an area of 1cm$^2$ have been obtained and are shown in Figure 1(a). The optical angular response of the samples has been characterized in our in-house Fourier microscope, shown in Figure 1(b). As we expect from Finite Difference Time Domain (FDTD) simulations the optical properties of the samples depend strongly on the period and the morphology of the grating channels .[5] Figure 1(b) shows reasonably good broad band absorptance, this is currently being limited by the nanoimprint process not achieving sufficiently deep grooves.

Molybdenum is a refractory metal with an even higher melting point than nickel (above 2000 °C) which is often used for industrial applications. It has not yet been explored for applications in the visible range, firstly due to its high losses and, secondly, the inability to couple to surface plasmons due to its optical properties. However, molybdenum does have a large value for the imaginary part of the permittivity, making it an excellent candidate to produce high losses through Joule heating. Under these conditions we have developed a new design approach where molybdenum acts as a very lossy dielectric instead of a metal. Large samples have been laser etched with large period structures with periods around 10µm. Figure 1(c) shows and optical image under polarized white light and excellent black metal properties are observed.

The final objective of this work is to optimize the response of nano/micro patterned metal absorbers based on plasmonic metals and lossy dielectrics and combine them with a large area fabrication techniques to produce low cost solar-thermionics energy converters.

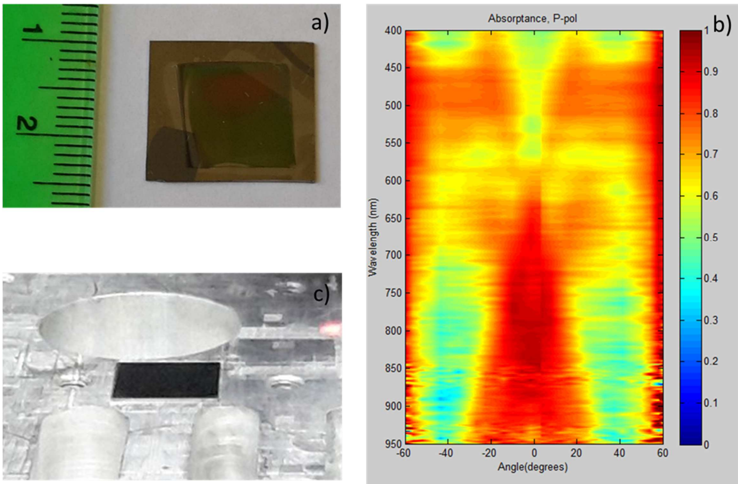


**Fig. 45. (a) Photograph of a nickel periodic nanostructure prepared from nanoimprint lithography with a commercial CD mask.**
**(b) Angular response of the nickel sample of Figure 1.a.**
**(c) Image of a molybdenum patterned sample under linear polarized white light.**

References


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