Infrared Phase-Change Metadevices with in-situ Switching

Yat-Yin Au, Santiago García-Cuevas Carrillo, Carlota Ruiz de Galarreta and C. David Wright
Department of Engineering
University of Exeter, Exeter EX4 4QF, UK

We describe a device design approach and experimental test platform[1] for the realization and characterization of phase-change metadevices incorporating *in-situ* switching and operating at infrared wavelengths. Measurements on a prototype device at 1.55 µm are presented.

DESIGN: The proposed metadevice[2] is illustrated in Figure 1(a) and (b). The bottom Ti\Pt layer serves as an integrated micro-heater, used for *in-situ* thermal switching of the phase-change layer. Since the device is designed to work in reflection, a bottom aluminium layer acts as a mirror. The phase-change layer is $Ge_2Sb_2Te_5$ (GST) and is kept thin enough to be easily fully crystallized and re-amorphized by the integrated heater. Si_3N_4 encapsulation and spacer layers ensure physical and chemical stability, and their high (for a dielectric) thermal conductivity ensures adequate heat dissipation. The top layer is an array of patterned aluminium squares that acts as an optical metasurface. When the GST layer is in the crystalline phase and the period and width of the aluminium squares is chosen appropriately, the device has essentially zero reflectance at the target wavelength of 1.55µm. However, when the GST is switched to the amorphous phase, the reflectance is high, as shown in Figure. 1(c).

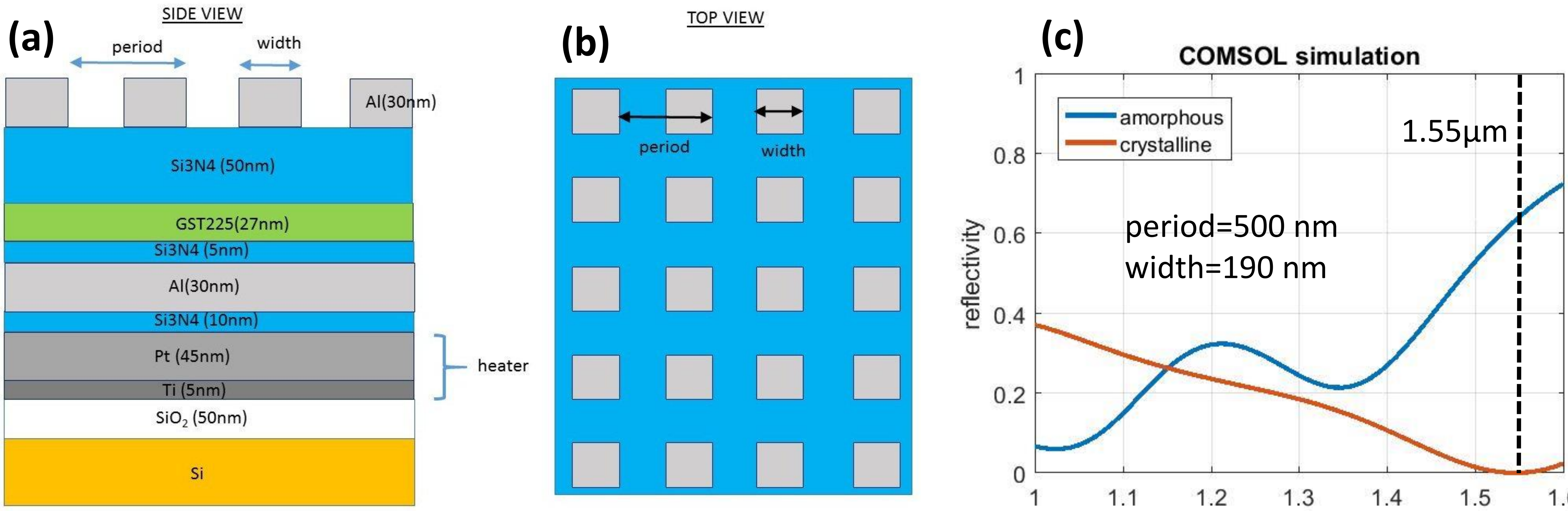
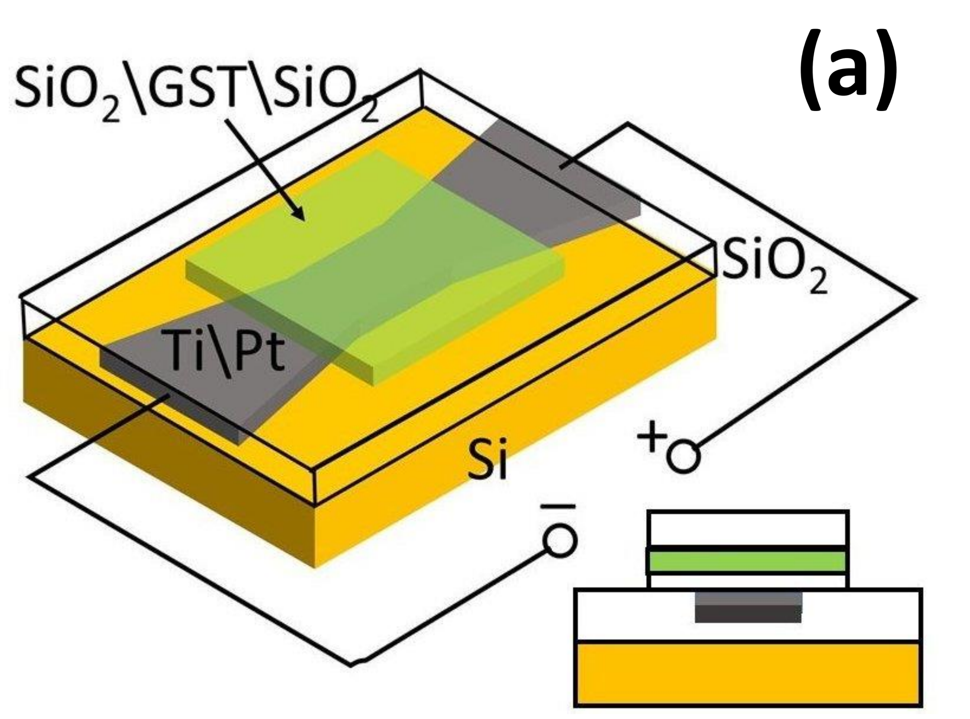


Fig. 1 Design of phase-change metadevice (infrared absorber/modulator)

EXPERIMENTS: Figure 2 shows our experimental system for characterizing metadevices and the first stages in development of such a device. (a) A prototype metadevice with a Ti\Pt bottom heater and a GST active layer, here sandwiched between SiO_2 layers. (b) Optical micrograph of the device in as deposited state and (c) crystallized and (d) re-amorphized by passing electrical current pulses through the integrated heater. (e) Electrical pulses applied to the heater for SET and RESET of the GST layer. (f) to (h) Reflectivity response of the device at wavelengths of 1.55, 1.30 and 1.05 µm, measured with an infrared spot of 3 µm diameter as shown in (b). (i) Illustration of the all purpose optoelectronic probe station utilized to perform the measurement. Pulse generator (18) and (27) provide the necessary excitation to the sample at (14). Infrared and visible source at (35) and (15) provide illumination to the sample device. Reflectance spectra are captured by spectrometer at (38) and (42) respectively. The overall measurement range of the set up is 200 nm to 1650 nm.



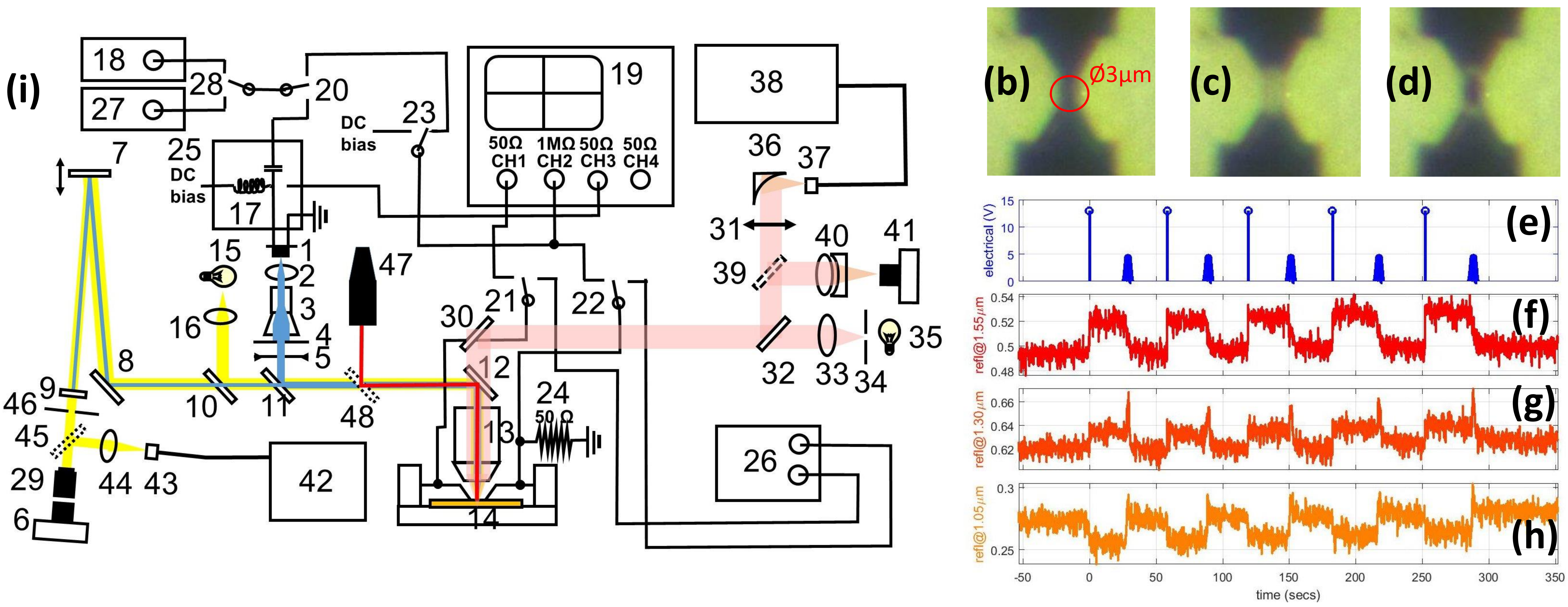


Fig. 2 Prototype metadevice (a-b), its in-situ switching (c-e) and infrared response (f-h); (i) shows the measurement system

References

[1] Y. Au, H. Bhaskaran and C. D. Wright, Scientific Reports **7**, 9688 (2017)
[2] S. G.-C. Carrillo, G. R. Nash, H. Hayat, M. J. Cryan, M. Klemm, H. Bhaskaran and C. D. Wright, Optics Express **24**, 13563 (2016)