Many-Body Thermal Sensor Misleading

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I. Introduction

An object can be found and identified by detecting its scattering signature of various physical fields, e.g., electromagnetics [1], acoustics [2], thermotics [3][4][5], etc. Similar to optical illusion, thermal camouflage device [6] can replace an expected object without changing the heat scattering pattern of thermal flux in background environment.

we propose and realize a two dimensional thermal camouflage device, which is capable of controlling the heat flow and can be used as a thermal sensor misleading device. This structure contains randomly distribution particles that can tailor many-body local field effect and overcome several limitations for practical manufacture of thermal camouflage device.

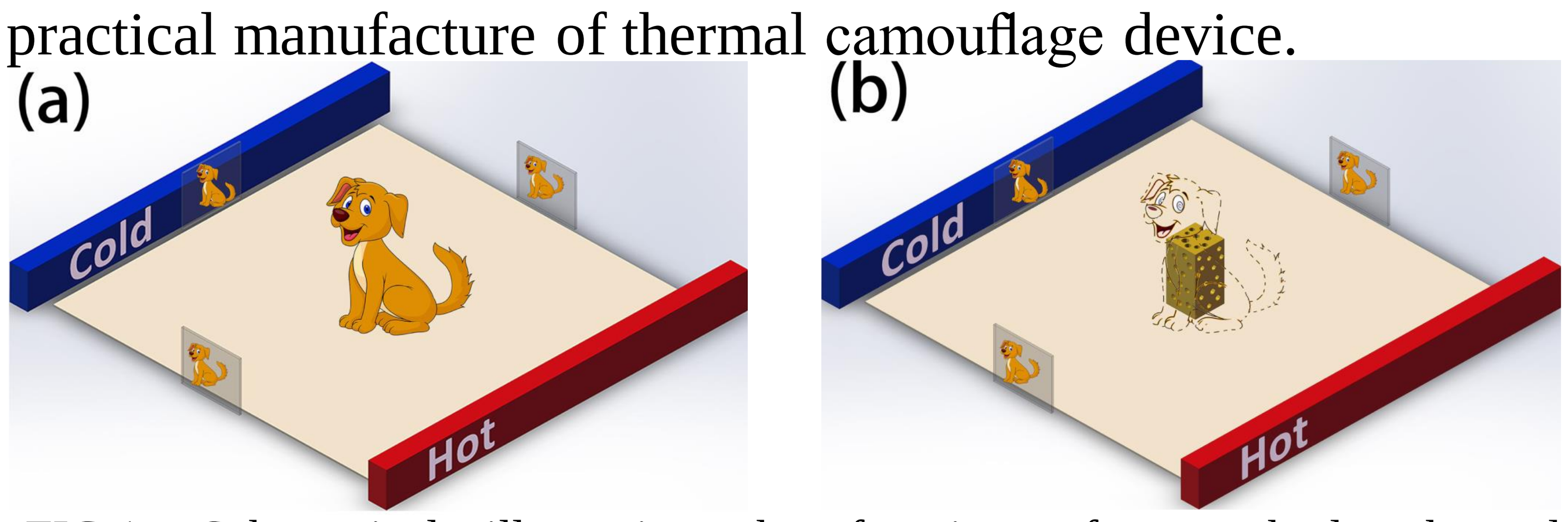

FIG.1: Schematical illustration the function of many-body thermal camouflage device. (a) Three thermal sensors can detect a dog in the heat conduction filed. (b) Well designed many-body camouflage device can 'deceive' thermal sensors giving them a same thermal signature of the dog.

II. Experiment

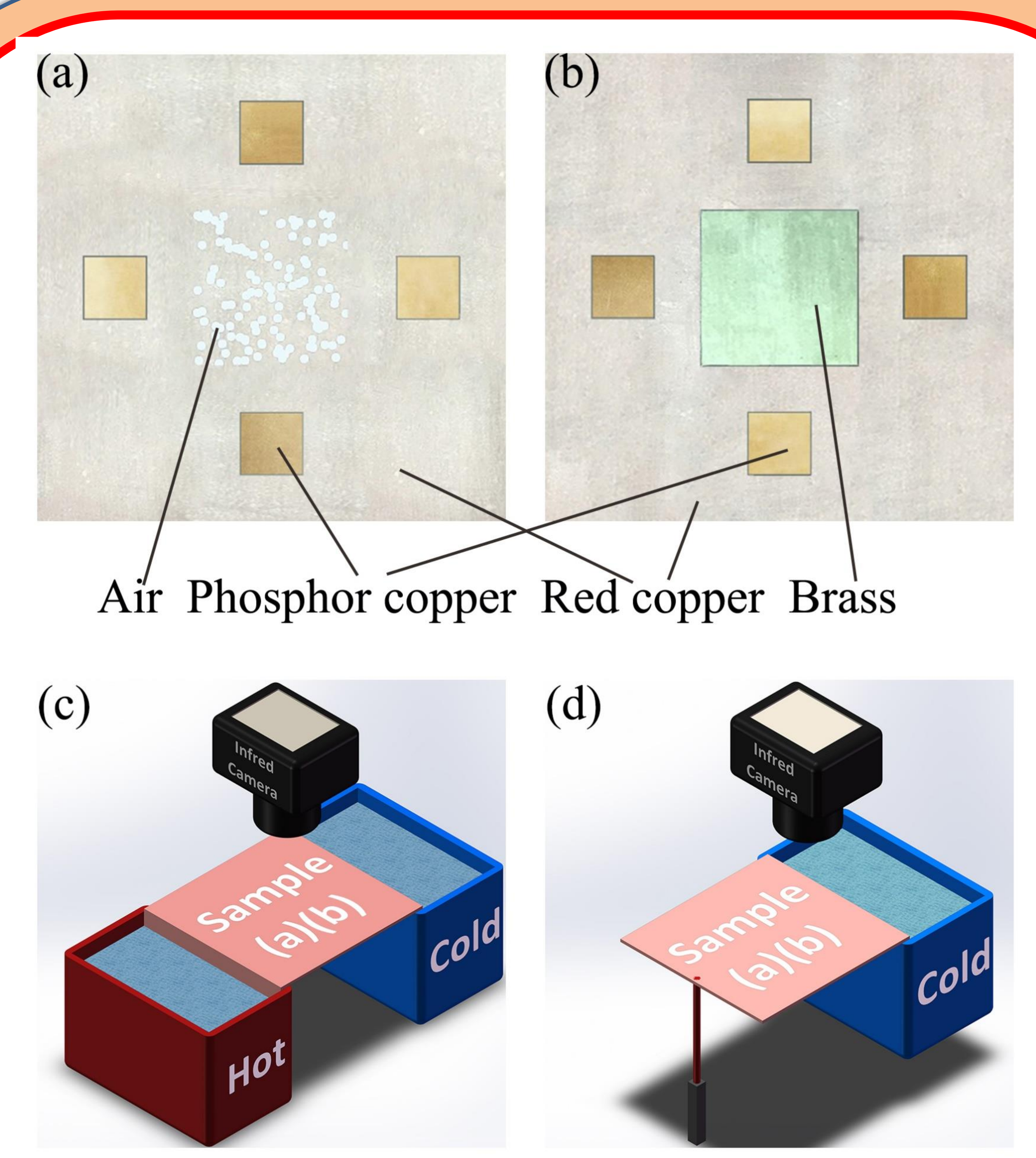

FIG. 2: Schematic illustration of all experimental samples (a)(b) and setup (c)(d). Brass with thermal conductivity 148 W/(m K) is serving as an expected object. For the many-body structure, the central square area contains air particles of thermal conductivity 0.026 W/(m K) and area fraction 31.03% randomly embedded in red copper of 390 W/(m K). Four small square phosphor copper areas play the role of thermal detectors.

III. Results

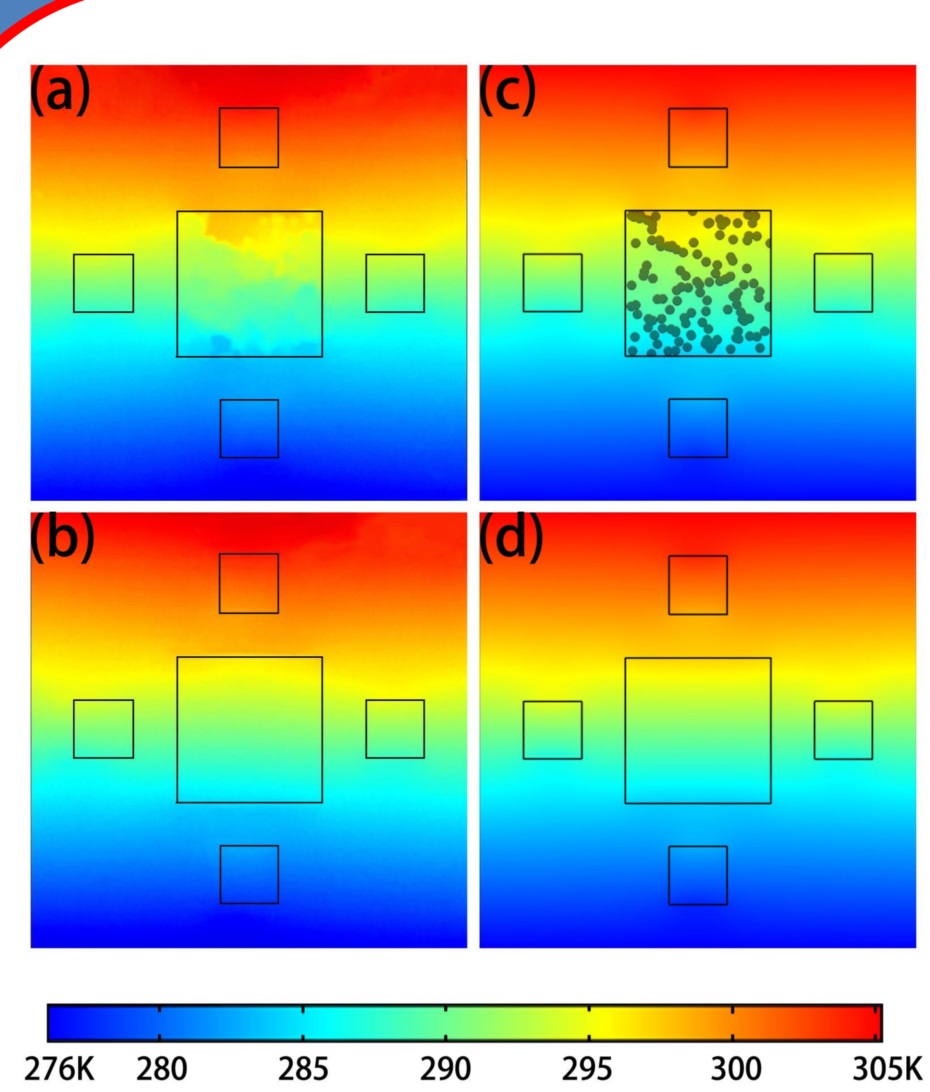

FIG.3: Experimental (a,b) and simulation (c,d) comparisons of temperature distribution for many-body structure (a,c) and expected object (b,d) under line shaped heat and cold source condition.

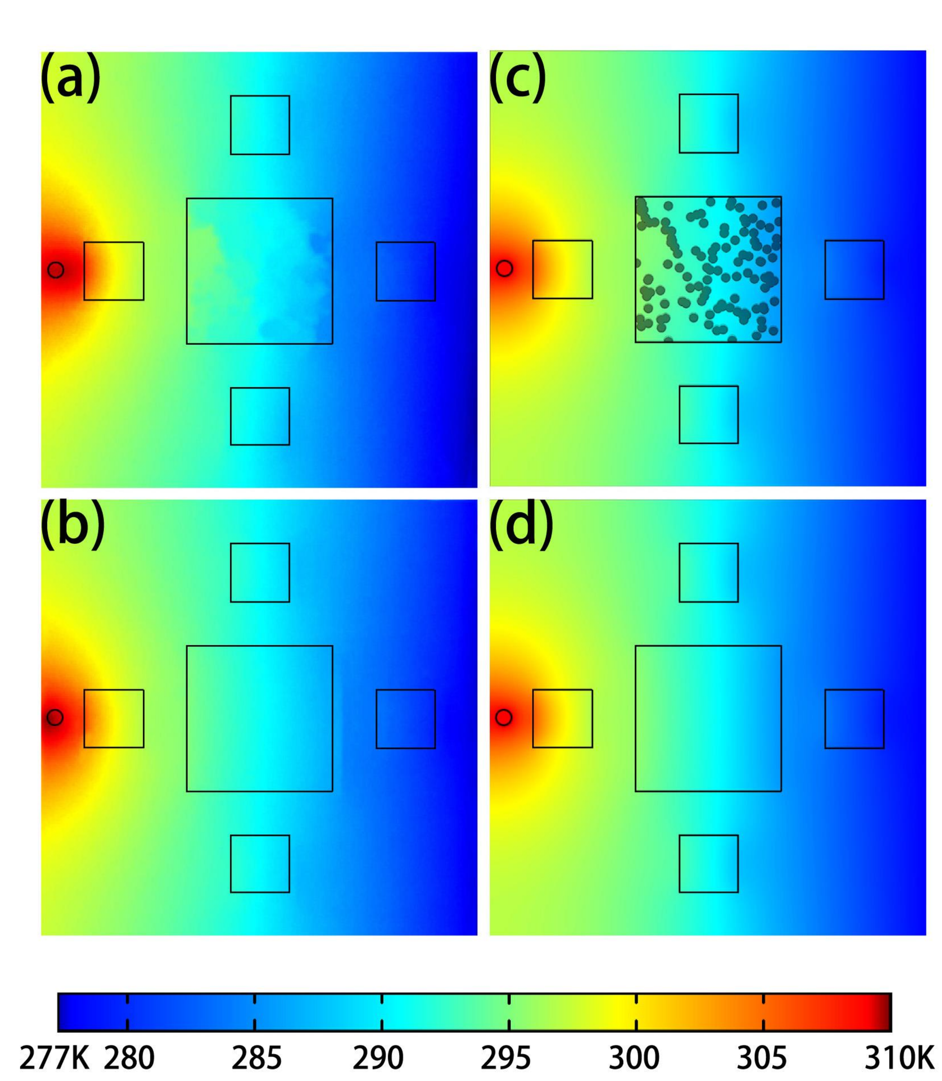

FIG.4: Experimental (a,b) and simulation (c,d) comparisons of temperature distribution for many-body structure (a,c) and expected object (b,d) under point shaped heat and cold source condition.

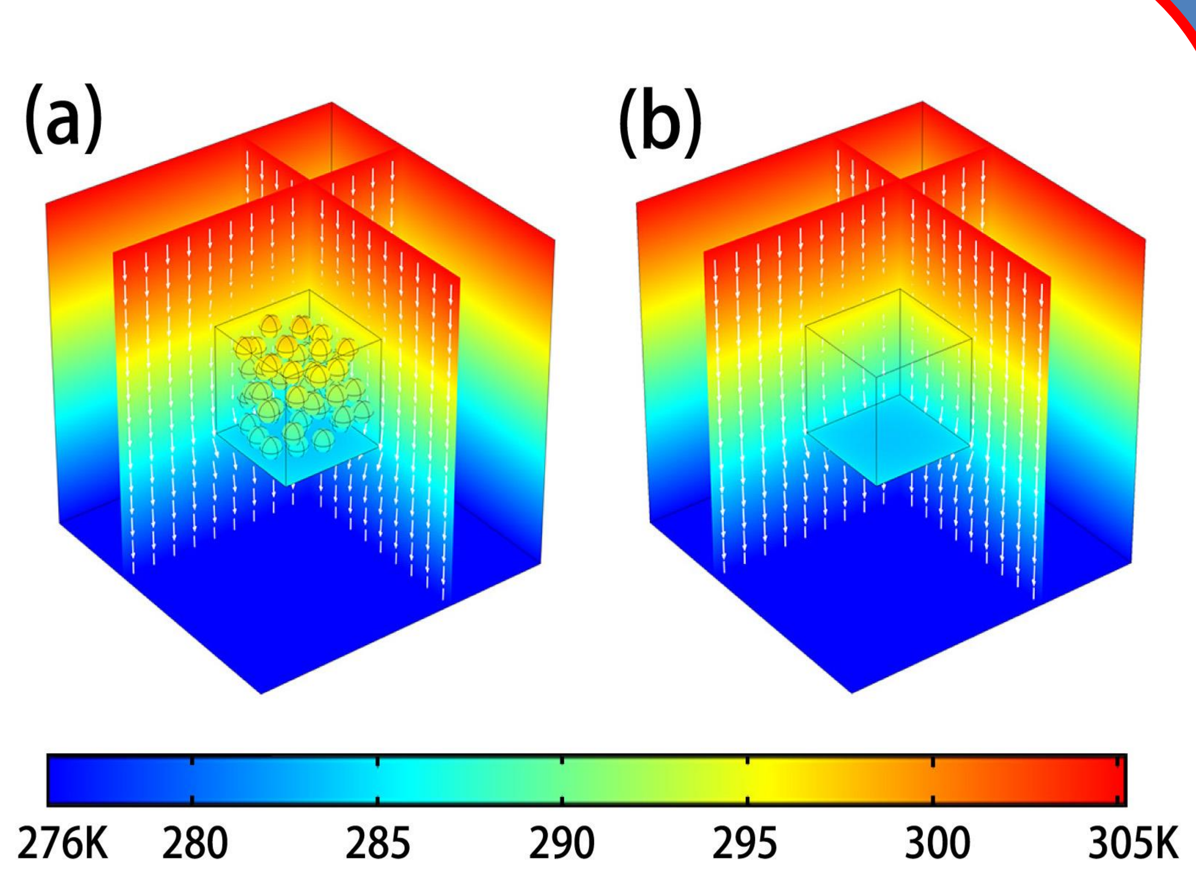

FIG. 5: Finite element simulation result of temperature distribution and heat flux arrow for three dimensional many-body structure (a) and expected object (b)

IV. Conclusion

In summary, we have demonstrated a many-body thermal metamaterial which can be used as a sensor misleading device. The agreement between experiment and simulation shows a good sensor misleading phenomena has been achieved in both line shaped and point shaped heat source situation. Three dimensional simulation has also been given which is more practical and commercially available in future camouflage device design.

Reference

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